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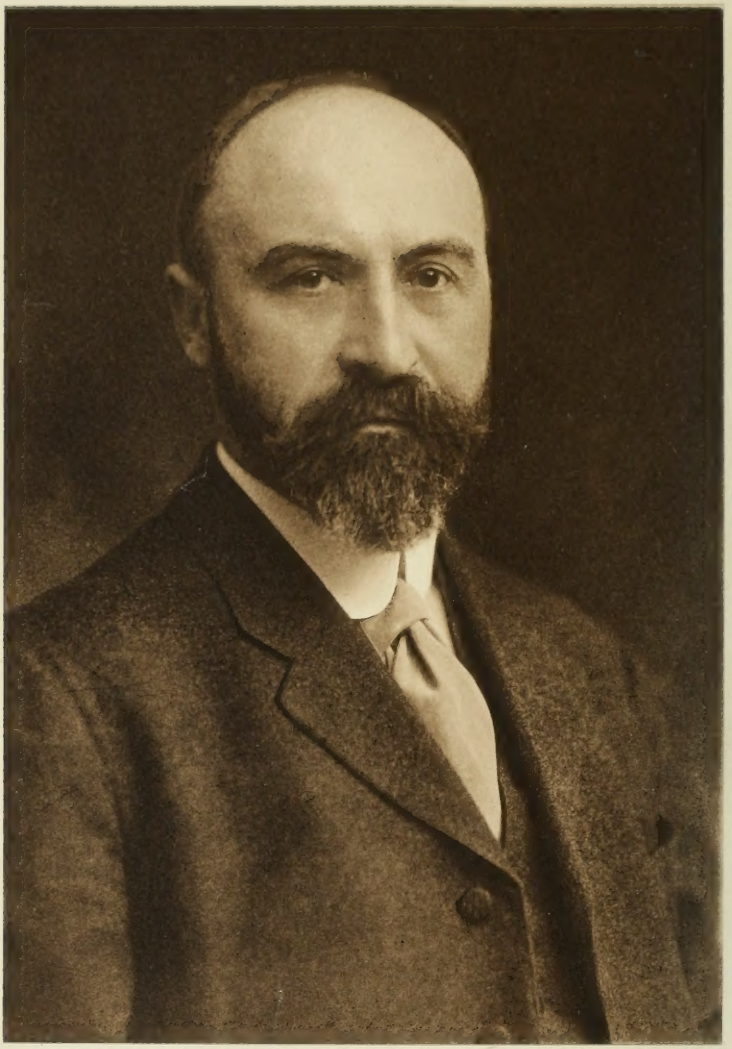

L. H. Baekeland

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TRANSACTIONS

OF THE

AMERICAN INSTITUTE

OF

CHEMICAL ENGINEERS

VOLUME IV

1911

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TRANSACTIONS OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

THIRD SEMI-ANNUAL MEETING

HELD AT THE CONGRESS HOTEL, CHICAGO, ILLINOIS, JUNE 21 TO 24, 1911

MEETING called to order by the President, F. W. Frerichs, at 10:30 A.M., Wednesday morning, June 21st.

The PRESIDENT:

The first number on the program is an address of welcome on behalf of the Mayor of the City of Chicago by Mr. Edward F. Wade, Assistant Corporation Counsel.

Mr. WADE:

Mr. Chairman and Gentlemen: Owing to the manifold duties which are attached to the office of the Mayor of the second city of the country, it was impossible for him to be here in person to extend to you gentlemen who have come from far and near to attend this convention the cordial welcome he desires you to receive. I am here as his direct representative, however, to tell you that you are welcome to our city, and to tell you in his behalf that he himself has watched the progress of men of your science for many years past. He has a peculiar faculty in that line, having made a study of engineering in its different branches both as a student in college and by reading since he left college.

I don't know that you care to hear any address from me, in fact, I am not prepared to make one, and in my position owing to the heat I can't help but be reminded of the story of the good old Catholic priest who was far famed for his eloquence but who had the habit of talking at great length. On this particular occasion he chose for his subject the place that Hebrew Prophets should have in sacred

history. He talked for an hour about the place the Major Prophets should have, and the congregation was sure he was about to conclude when he talked another hour about the place the Minor Prophets should have. The congregation was certain he was to conclude, when he said, "Now, my Brethren, I have assigned a place in sacred history to the Major Prophets and have assigned a place to the Minor Prophets, what seat shall I give Malachi?" A young fellow in the back part of the church who appreciated the eloquence of the old priest but not the length of his sermon arose and said, "Reverend Father, if there do be no objection, Malachi can have my seat. I am going home." So I don't want to talk so long that somebody will want to give up his seat here.

Gentlemen, all I can say to you is to let your watchword be onward in your splendid work. It is a great work; let it be onward for the development of men; onward for the spirit that has made our country great in its origin and greatest in its present day development.

Again on behalf of the Mayor I extend to you the welcome of our city. I suppose someone will be here to guide you about. You will find many interesting features in our city, and I want to extend an invitation to you to come over to the City Hall and the County Building, and if at any time you are over there come to the Corporation Counsel's office and ask for me and I assure you we will not only go through the City Hall and the County building, but there are many places where we can be refreshed in the neighboring buildings (applause).

The President responded to the address of welcome as follows:

In the name of the members of the A.I.C.E., I thank his Honor, the Mayor, through Mr. Wade, for the hearty welcome which he has extended to us. I myself am not so far from Chicago, since I live in St. Louis, and I may well say that the West of our great country has been my home for thirty years. I have seen the country develop and have seen the cities grow until now business activities in our great cities give testimony of the westward trend of many of our great manufactures.

The great packing industries, which were centered in Cincinnati fifty years ago, have developed in this city to the greatest dimensions and are decreasing now to travel to more western points. But in their track they have left splendid institutions of art and learning, which have become possible only by successful industrial enterprises,

and these institutes of learning in their turn have spread knowledge and science, from which have sprung more advanced industries, which need the highly trained minds of engineers. We find the gigantic Harvester and Pullman works and we will have an opportunity of inspecting the most modern iron plant in Gary, the oil refineries in Whiting and probably the most extended plant for refining of corn products.

Particularly, however, am I glad to meet you here, my fellow members, at a time when the highest court of the country has proclaimed what we may call the "emancipation of mind." The letter of the law, which has dominated our country for many decades with utmost tyranny, must give way to the rule of reason, and we well may admire the courage of the highest court, which by its action has declared the people of the United States ripe to be governed by the spirit of their laws. I presume that there is nobody now to seriously contend that combinations of capital, organized to promote economies in management, to facilitate exchanges, thus logically reducing cost of production and distribution, will ever be wiped out. Nor is there any doubt that combinations of labor, which demand betterment of the laboring classes by means which are free from coercion and violence, will be fully approved by the employers in the industries. Therefore, have I the greatest confidence that our people will justify the freedom, thus given them, and that the good common sense and the earnest desire to do right, which is, undoubtedly, inherent in every American citizen, will not tolerate that the rule of reason as defined by the Supreme Court of the United States will be misused by actions of our lawmaking bodies and in decisions of our courts.

It is one of the aims of our Institute to obtain recognition by municipal, State and national authorities in public works. We chemical engineers are trained to make our own laws, but we let ourselves be guided by them only as long as our good common sense and our reason commands.

Therefore, we must be particularly satisfied that our way of drawing conclusions, which is the way of all well trained engineers, will govern more and more in business life and in our courts and we may confidently look for growing influence in all questions requiring the true judgment of a chemical engineer.

However, I will not take up more time and I wish to thank you, Mr. Wade, for the cordial welcome which you have extended to us.

Mr. WADE:

Well, gentlemen, the City of Chicago pays me for being over at the city Hall. I am awfully glad to have met you, and hope you will come over and see me.

The PRESIDENT:

The next order of business is the reports of Officers and Council. I believe our Secretary, Dr. Olsen, has these reports.

Secretary OLSEN:

The report of the Treasurer which the Society always likes to hear has been delayed in the mail, but will probably reach us before the end of our meeting. I will now read the report of the Secretary.

REPORT OF SECRETARY

June 19, 1911

THE correspondence for most of the activities of the Institute is carried on through the office of the Secretary. From this office, all publications of the Institute are also issued.

The work of the Institute is divided amongst a number of Committees. These Committees hold meetings from time to time as matters for action come up, and decide upon the general policy, and in some cases, the details of the work to be carried out. The Secretary, so far as possible, attends the meetings of each Committee in order to keep in touch with the work.

One of the most important Committees is that on membership, and a great deal of the correspondence of the Secretary's office is concerned with the applications for membership. A very large number of requests for information with reference to conditions of membership are received. These are very promptly answered and literature sent to applicants, including application blanks. The number of applications may be inferred from the fact that 1000 application blanks were printed immediately after organization three years ago. These are now exhausted, while our membership list is about 150. Very little change was made in printing the new application blanks, the chief one being the insertion of a blank for indicating the grade of membership for which application is made. Most of the new members are obtained by the personal solicitation of our present membership. It may be possible in the near future to so

organize our work that applications received by the Secretary for information could be referred to a local member of the Institute who could call upon the interested chemical engineer and explain fully the objects and working of the Institute. This would probably result in a considerable increase in membership. The opinion of the Institute is desired upon this suggestion. While the minimum number of references called for is five, it has been found necessary to refer to two or three times this number in some cases, in order to secure sufficient information for recommendation to membership.

A certificate of membership has finally been prepared at the direction of the Membership Committee, and will be ready for delivery to members within a few weeks. Design for seal has also been accepted and a steel die made, of which impressions will be made upon the certificate of membership in gold. The certificate has been printed in three colors: black, red and gold.

Another very important committee is the Publication Committee. All papers received for publication are passed upon by this committee, so far as possible, every member reading each paper. This results in very careful criticism of the language of the paper, the literary form, and also in many cases brings out suggestions for improvement, as well as in a very few cases, the rejection of papers of little value. After papers have thus been passed upon, the Secretary prepares them for the printer and secures the publication either in bulletins or transactions, all the work of publication being carried on through the Secretary's office.

Volume III of the transactions is at present being printed. It was hoped to have this ready for the present meeting, but the loss of six papers in a single package in transmission through the mail from one member of the Publication Committee to another, resulted in serious delay. The Secretary finally secured duplicate copies of each one of these papers. The increase in size of the volume also necessitates more time for the printing. Our first volume contained 11 papers and 204 pages; our second volume contained 19 papers and 308 pages, while the third volume will contain 25 papers and about 410 pages. This shows a very gratifying growth.

One bulletin has been issued since the last meeting, namely, that of December, 1910, on the general subject of Chemical Engineering Education. A great many calls have been received for this bulletin, which has had a fairly wide publicity. The questionnaire sent out

with the bulletin has aroused a good deal of discussion on this subject, which is the basis of the report of the Committee on Education.

A new list of officers and members has also been printed. This list contains 1 honorary member, 132 active members and 12 junior members--total 145. Our last list contained 121 active members—a net gain of 24, showing this year's growth of 11 active members and 12 junior members.

The Committee on Medal has been active in securing funds for this object. A circular letter has been sent out from the Secretary's office, soliciting subscriptions, as a result of which, a considerable amount has been received, which is included in the report of this committee.

The work of the Finance Committee is carried on mostly through the Auditor and the Treasurer. The Committee on Meetings has during the current six months been greatly assisted in their work by the very complete organization of the Local Committee here in Chicago, who have done most of the work of preparing this meeting. Papers have been secured through the Secretary's office for this meeting after a great deal of correspondence and solicitation. There is no doubt but that a great deal of technical material is locked up in the desks and minds of many of our members. Owing to the press of other duties, considerable urging is necessary to bring this out. It is hoped that members will volunteer as much as possible the publication of investigations which have been carried out.

Some correspondence has been carried on with reference to a meeting place for the annual meeting in December. Boston, Baltimore and Washington have been suggested. Members should express their preference at this meeting for one or the other of these localities.

Respectfully submitted,

J. C. Olsen,

Secretary.

The President:

Gentlemen, what is your pleasure in regard to this report?

Mr. Bement:

I move that it be received.

Which motion was duly seconded and unanimously carried.

The PRESIDENT:

Gentlemen, there is a recommendation made by the Committee on Membership in regard to changing the mode of application for membership. You have heard that. What is your pleasure in regard to this question.

Secretary OLSEN:

There were two points made. First, that as the Chicago local committee met and recommended a certain number of men for election which has resulted very satisfactorily, the extension of this idea was suggested. If a man from Cleveland, for instance, applied for membership, or desired to join the organization, his name should be referred to the Cleveland members who would call on him and explain the objects of the organization, and make it clear to him just what is required by the organization. The question is, whether such procedure is desirable.

Dr. WAGNER:

It seems to me before you can carry out a plan of this sort you will have to organize the Institute into local committees, which I do not understand is the case to-day. The formation of the Chicago local committee was brought about solely through this meeting, and I do not know that the Chicago members would have acted in that matter if it had not been for the preparation for this meeting.

The PRESIDENT:

Certainly I should think that an arrangement of that kind would be a very desirable one. I myself have had quite a number of inquiries from young men who would like to know whether they probably would be received as members. Of course, I could not give any advice, and only could ask them to make application and take their chances. If committees existed which could give them some assurance we certainly would have more applications for membership.

Dr. SADTLER:

As I understand, the applications have come in from strangers and they have been given the names of the members of the Institute who reside in their own city and told to get their endorsement. Has that been done at all in the past?

Secretary OLSEN:

That is what they don't do, and that is where trouble arises. A man wishing to know the conditions of membership writes me and I send him the literature and write him a letter, but frequently hear no more from him.

Dr. SADTLER:

I do not think the Institute is strong enough to organize local sections for any other purpose except to act as a kind of committee to recommend and pass upon local applications. We are not strong enough to have local sections because our membership is not large enough except in three or four of the large centers. It would be very desirable for a young man not generally known to be given the names of four or five members of the Institute residing in his section, upon whom he could call and make himself acquainted. If those gentlemen would then endorse his application it would undoubtedly go through the Membership Committee.

Secretary OLSEN:

The point is that the Chicago committee knew all these men and knew they were qualified. You can increase the membership much more rapidly by inviting well-known chemists to become members than to wait for them to make application. That was the governing thought in this case in Chicago, and I think that it holds good generally. The men that are eligible should be invited to become members of the Institute. I think only in that way can we look for a rapid increase in membership.

Dr. SADTLER:

Mr. President, couldn't it be gotten in shape in this way: appoint a committee to draft a resolution expressing approval of this scheme to be presented at the subsequent business meeting, and then we can pass it formally.

Secretary OLSEN:

Do you make that a motion ?

Dr. SADTLER:

I don't make it a motion because I think it ought to come from the Chicago gentlemen acting in this matter.

Dr. GUDEMAN:

There might be a great difference between a member recommending a person for membership and the idea of the committee. I know of one specific case where a gentleman inquired of me and I told him I would be very glad to receive his name and I would submit his name, and afterwards he got a notification that they thought his qualifications were not satisfactory or not sufficient for him to become a regular member. It surprised me very greatly. He is a member now, but it surprised me that my opinion regarding his qualifications did not meet at all with the approval of our Secretary, who thought he wasn't a competent man to become a regular member. In this case the message went to the gentleman that he would have to send in his qualifications, that they did not believe he was fit to become a regular member. He was one of the best chemical engineers in the West. So even if you have a gentleman whom you might think can become a member and you put in his name, who is to decide whether he gets in or not?

The PRESIDENT:

Of course, it could only be a very strong endorsement for the consideration of the Membership Committee.

Dr. WAGNER:

The point I am trying to make is that you can avoid all these difficulties by having the Committee on Admissions invite a man to become a member. Then his status has been settled before he puts in his application. The way we did in Chicago with the six, eight or twelve men, we considered each one of these men eligible for membership, and we sent you the sketch. Of course, with such endorsement I think the chances are decidedly in favor of the candidate.

The PRESIDENT:

It has been suggested that a committee be named to put this question into a definite form and report at the next business meeting. Is that put in the form of a motion?

Dr. GUDEMAN:

I will make a motion to incorporate that idea.

Dr. WAGNER:

I second that motion.

Motion unanimously carried.

The PRESIDENT:

I will appoint Dr. Wagner, as chairman, Dr. Gudeman and Dr. Sadtler to serve on this Committee.

The report of the Committee on Membership is next.

SEMI-ANNUAL REPORT OF THE MEMBERSHIP COMMITTEE

FOUR meetings of this committee have been held since the annual meeting in New York.

Thirty-one applications have been received; 23 were for active membership, and 8 for junior membership; 28 applications have been acted upon as follows: 15 were recommended for election to active membership; 6 were recommended for junior membership. Three active and 1 junior applications were denied; 3 have been laid on the table until further information is received; 3 applications have not yet been acted upon.

In most cases, the rejected candidates lacked the experience in applied chemistry required by the Constitution. In a few cases, candidates showed a tendency to overstate the amount and character of their technical experience.

Four Institute ballots for members were taken, upon which there were 17 candidates elected for active membership, and 6 candidates for junior membership. With one exception, all candidates were elected. Five negative votes were cast for the defeated candidate, the reason assigned being the fact that the candidate was not engaged in technical work at the date of election.

The design for an Institute seal was adopted by the committee, and has been prepared. The design and wording of the certificate of membership has been decided upon by the committee, and has been printed. These certificates of membership will soon be ready for distribution to members. It was decided to have certificates signed by the President who was in office at the time members were elected.

The application blank was modified to provide for junior as well as active membership.

Respectfully submitted,

A. C. LANGMUIR,

Chairman.

The PRESIDENT:

Gentlemen, what is your pleasure in regard to this report:

Dr. GUDEMAN:

I move that it be received.

Which motion was duly seconded and carried.

The PRESIDENT:

The next report will be that of the Medal Committee.

The Secretary then read the report of the Medal Committee as follows:

REPORT OF THE MEDAL COMMITTEE

Syracuse, N. Y., June 16th, 1911

Dr. F. W. FRERICHS,
Chicago, Ill.,

Honored Sir:

At the last meeting of the Institute, your committee was instructed to collect money and select a design for the medal. In response to a circular letter sent by the chairman, through the courtesy of our Secretary, to all members, enough money has been promised to warrant the selection of an artist and the execution of an appropriate design. With the subscriptions which have been generous and representative have come many suggestions relating to the medal itself. The general opinion is that the bust of no chemist or chemical engineer living or dead ought to appear. Some have proposed a symbolic design; others that the words "Institute Medal" be used alone on the obverse, with the name of the recipient on the reverse, introduced in an appropriate way. It has been generally understood that the material of this gift should be gold, although iron and bronze are metals that are used for such purposes, besides the latter are less negotiable, and, therefore, represent greater honor.

Your chairman suggests that a rare metal or alloy that would withstand the attack of the elements, and that would be capable also of receiving impression of the die and retaining this might be considered.

In this whole matter my own ideal has been an early Greek coin which represents, I believe, the most advanced stage of the art.

Mr. Whitehouse, of Messrs. Tiffany & Co., has kindly lent us

his time and highly artistic talent in two designs, photographs of which accompany this report. These photographs have been sent to members of the committee. No member favors the Palissy design. Mr. Robertson objects strongly to this and more mildly to the second and intimates that we had better try again.

Since this subject has been deferred so long, I suggest that a discussion be called by the President in open meeting. Of inartistic and expensive medals, there are already too many. We want something unusually good, consistent, of course, with our purse and aims.

We take this opportunity to thank members for such a ready response to our appeal for money and opinions.

Respectfully submitted,

WM. M. BOOTH,
Chairman.

Secretary OLSEN:

Aside from the design which is being passed through the audience another design has been prepared pursuant to suggestion, which I shall also pass through the audience. This second design has been prepared to symbolize the connection between the investigations carried on in the chemical laboratory and the factory. You will notice on this design that a chemist is shown working in a laboratory, and through the open window can be seen the factory with the chimneys and buildings symbolizing that his work is carried on with reference to the factory. On the reverse appropriate wording gives the object for which the medal is presented, the year and the name of the recipient. Now, if this design is acceptable to the Institute you may desire to change the particular apparatus with which the chemist is working. You will notice there are a Hempel gas burette, a balance, a desiccator, crucible tongs and a test-tube rack.

The PRESIDENT:

Gentlemen, you have heard the report. The first question to be discussed is perhaps the money question. I understand there is $275 available. I also understand that it costs about $250 to make the die and $40 for the medal itself, and it is recommended by Tiffany that besides the gold medal a replica in bronze be struck and kept by the Treasurer or in the archives of the society. This will make, in addition to a nice case which will cost $4 or $5, $50 for each medal to be awarded. Now, $100 of this fund is given for a permanent fund,

and I believe that there will be no difficulty in inducing the donor to make this $100 available for getting the die, because the die will be permanent, and no doubt we will have further donations so that the Institute can continue to award a medal. If this is your opinion the Secretary might be instructed to correspond with this gentleman and get the donor of the $100 to consent. In that way we will be able to get the die made right away, otherwise, we would have to make further collections in order to get the necessary money, or else I believe the Society as a society could advance the money as we are fairly assured of getting whatever is necessary.

Secretary OLSEN:

Mr. President, I think that more money will come in. This $275 has come in from thirteen members.

The PRESIDENT:

I certainly think we can go ahead with ordering the medal. Is there any motion in that regard?

Dr. WAGNER:

I make that motion.

Motion seconded.

Secretary OLSEN:

Just what is the motion?

The PRESIDENT:

That the Committee should go ahead and order the die for the medal and have the medal struck.

Secretary OLSEN:

Is the subscription to continue and the funds raised in that way?

The PRESIDENT:

Yes.

Secretary OLSEN:

I do not feel, Mr. President, that we ought to ask the donor of the $100 to change in any way his donation, as he expected that to be a permanent fund, and I think he would expect that it should be put at interest, and I am pretty sure the Treasurer has already done so. The Trust Company gives 5 per cent interest on a certificate of deposit which cannot be drawn upon under a year, and I think

it would not be quite right to ask the donor to change it to any other fund. I think it would be better if we continued getting subscriptions.

The PRESIDENT:

Gentlemen, what is your pleasure in regard to this question?

Secretary OLSEN:

I should like to know just what the motion is.

Dr. GUDEMAN:

As I understand the motion, I seconded it, the committee is to be authorized or empowered to take final action on the medal.

Which motion was duly seconded and unanimously carried.

The PRESIDENT:

Now, the next thing would be to have some expressions on the design of this medal.

Dr. GUDEMAN:

Is it necessary to decide on the design of the medal right here? Is quick action required?

The PRESIDENT:

No, but it would be desirable to have expressions of opinion, and we could decide later on. We could have an expression of opinion here and we could take a vote on it say day after to-morrow at the last business meeting in the evening.

Dr. GUDEMAN:

On the last design just talked of there seems to be a unanimous opinion that it does not represent anything in chemical engineering. The picture, if there is to be a design, should be something that really refers to chemical engineering. All that this is, is a picture of a chemical laboratory.

The PRESIDENT:

As I understand, Dr. Gudeman would like to have further designs submitted to the society and its members.

Dr. GUDEMAN:

Yes.

Dr. WAGNER:

Mr. President, I think this is an important matter; it ought to be representative of our Institute, and we ought to give it more time. I personally feel that I would not want to vote for either of these designs.

The PRESIDENT:

Do you make a motion to that effect?

Dr. WAGNER:

I would like to ask a question first. I don't know how long this matter can be held in abeyance. Can it go over until the next meeting of the Institute for final action? Surely the Medal Committee would pass on it ultimately.

Secretary OLSEN:

We have a Medal Committee and the Medal Committee has received a lot of suggestions, and the opposition to putting the bust of some chemical engineer on the medal seemed to be very pronounced, and we would like to know if that opposition exists in this meeting. There has been suggested Solvay, for instance, who was the engineer who designed the Solvay process, a very important process; Mund and Palissy have been suggested, the latter being the man who designed enamel ware, and one of the earliest workers; and Knietsch has been suggested. A number of men of that type have been suggested as appropriate, and on discussion they have not met with favor. Now, we would like an expression of opinion here as to whether you wish the committee to search the history of chemistry for a representative individual and put his bust on the medal; or if you wish a symbolic design. Now, for symbolic designs, one member suggests SO_3, to work out something with reference to the sulphuric acid industry, and that is as far as he will go. Another member suggests a cannon with an arrow; which would typify the energy of the gunpowder, and the swift movement of chemical industry. We have had suggestions of that kind, but nothing that has met with general favor. This design which you have just said is not representative was designed to show the connection between the laboratory and factory. If you have any suggestions as tohow the idea can be carried out we would be glad to have them.

Dr. WAGNER:

Just as we were saying that we ought to have a smokestack through the window, my friend just back of us didn't want any smokestack or any smoke coming out of his stack because it was his business to keep the smoke out. The objection to an individual is that there is no universal chemical engineer; all the chemical engineers we have had are more or less specialists in their particular lines.

I would like to move that the matter be further investigated by the Committee, as I presume that the ultimate decision must lie with the Committee.

Secretary OLSEN:

Yes, but they would like to get the views of the Institute so far as possible.

Dr. SADTLER:

Couldn't your motion incorporate the idea to let the matter go over and have the Medal Committee invite designs and then submit to the Institute for final vote the two or three that seem to meet the most general approval of the committee.

Dr. WAGNER:

I put my motion in that form.

The PRESIDENT:

Perhaps it would simplify the matter for the committee if an expression could be given, whether the bust of a certain man who has done a great deal for chemical engineering ought to appear on the medal or whether a symbolic design would be preferable.

Dr. WAGNER:

I think we could take a vote on that right now.

Dr. GUDEMAN:

Mr. Chairman, I don't quite agree that we have no universal chemical engineer. I think we have, but we must go far back. The only man I think we could put on is Dr. Archamedes. If you take specific gravity, I think that comes into the whole metallurgical industry; if you take the application of power, I think we can stretch that to bring in power transmission. That comes pretty close to chemical engineering. I think if we put on any design it should be some design instead of being a laboratory. It is very

easy to get something showing the transmission of power, take water power or something of that kind. That is not specific of any one industry. I believe that to take the ceramic or sulphuric acid industry is not fair to the others. I do believe they could get up some sketch. The most representative and many-sided engineer we have now is Lunge; his work certainly goes further in the application of chemical engineering than any man I can think of; it is not one specific process.

The PRESIDENT:

As I understand the motion now it is desired by those present that the matter be referred back to the committee, and that the committee be asked to submit a set of designs leaving the character of the design entirely to the choice of the committee. Is that motion seconded?

Dr. SADTLER:

I second the motion.

The PRESIDENT:

There being no objection the motion is passed.

REPORT OF COMMITTEE ON STANDARD BOILER TESTS

Mr. BEMENT:

Mr. President: The committee can only make a report of progress, and state that it has met and considered a large number of questions. The chairman of this committee is the chairman of a similar committee of the Western Society of Engineers, and it was felt desirable in that work to have the consideration go on at one time. There was delay in appointing a committee from that society. That committee was organized a short time ago, and the chairman of the two committees has sent out correspondence to all members asking for suggestions in order to get ideas for the two committees. Very little came in. However, probably the most pointed and significant suggestion came from the other committee, which is a larger committee. Dr. Goss of the University of Illinois suggested that the chairman of the committee get together something for submission to the members so that the committee would have something to work on, and it seemed to me that it would be better

to pursue that plan with our Institute Committee. I am now getting together some preliminary matter for general discussion. The problem is a very complicated one, and in the opinion of some of the members of one of the committees there is too much confusion existing regarding the whole matter, particularly concerning the elementary features to attempt at the present time to formulate any rule. Just to illustrate one point without taking up too much time, it is not granted now that a boiler, that is the metal holder of water for the making of steam, has any individuality. Its efficiency as a device or metal structure for the absorption of heat is not conceded, but what is classed as the efficiency is the performance of the entire apparatus which is composed of brick wall, fire bars, coal, the character of the fire, the rate at which it is driven and a great many variables. That is the figure that we have been applying, misapplying very often, in two or three directions. It is the figure that we use when we want to test coal, when we want to test the boiler, when we want to test the furnace, or see whether the fire is good, the stoker is good, or see whether the combustion is good. Now, it is felt that some of those features should be further eliminated, and we should get together on a common basis so that when we do get something it can be received without dispute.

I trust that this report which I make will be satisfactory and at another meeting I promise to have something substantial.

The PRESIDENT:

I understand the chairman of this committee, Mr. Bement, makes a report of progress, and the Institute can hope for a fuller report at the next meeting. Gentlemen, do you receive this report? If there is no objection the report is received.

We will now have the report of the Committee on Chemical Engineering Education by Dr. Samuel P. Sadtler, Chairman.

The report* was then read:

The PRESIDENT:

Gentlemen, you have already expressed your thanks to the chairman of this committee, Dr. Sadtler, for his painstaking report, and I will defer debate or discussion on this question until the papers on the same subject have been read. I think it better to have the discussion at one time. Prof. J. H. James read a paper on

* This report will be found on page 218 of this volume.

" The Four-year Chemical Engineering Course." After the reading of this paper, Prof. James K. Withrow read a paper on " The Length of the Chemical Engineering Course, a Summary of the work and points of View of the Committee on Five-year Engineering Course of the Ohio State University."

The PRESIDENT:

Gentlemen, you have heard these excellent papers. Discussion will now be in order.

Dr. GUDEMAN:

It would be an absolute injustice to the gentlemen who have read the papers, especially the chairman of our committee, to try to discuss any of them in the length of time still left to us. I, therefore, move that these papers take the regular course, be printed and sent out with the other papers, and the discussion be postponed until our meeting in December, and that the Committee on Program be requested to allow plenty of time, a full day or a half day, at that meeting for the discussion of these papers.

Motion duly seconded and unanimously carried.

Dr. SADTLER:

I would like to ask the Secretary if he has a supply of those bulletins?

Secretary OLSEN:

I have.

Dr. SADTLER:

Then it might be well when these papers are printed to refer to the fact that Dr. Whitaker's and Dr. Atkinson's papers are still available for those who haven't them in hand, because I think that when we ask for an expression of views from the members of the Institute that they should have before them those important papers already published, the important papers presented to-day and the committee's summary. We must crystallize this discussion into more definite shape than it is now. The whole mass of information should, therefore, be considered.

Secretary OLSEN:

The contents of these bulletins will appear in the third volume of Transactions which all members will receive before the meeting, and there are also some extra copies of the bulletins; but every mem-

ber will have the Transactions and I understand this motion to be that I should publish these papers as a bulletin following this meeting and send it to all members. Is that the idea?

Dr. GUDEMAN:

It was not the intention to make that a part of the motion, to compel you to do it. Just let it take the regular course.

Secretary OLSEN:

If they take the regular course they will not be published until the fourth volume of transactions, but if you desire the members to have them in hand before the winter meeting you must authorize me to publish them in the form of a bulletin.

Dr. GUDEMAN:

Well, all right then.

The PRESIDENT:

Do you put a motion to that effect, that these papers be printed in the form of a bulletin and sent out and that the discussion be in December?

Dr. GUDEMAN:

Yes, sir.

The PRESIDENT:

If there is no vote to the contrary, it is so ordered.

The Secretary then announced the receipt of an invitation from the Sanitary District of Chicago to visit their laboratory; also made other announcements relative to the program.

The PRESIDENT:

If there is no other business we will now adjourn.

Meeting adjourned.

Wednesday Evening Session

June 21, 1911.

The meeting was called to order by the President, at eight o'clock.

President Frerichs read his address on Some Problems in Chemical Engineering Practice.

(*a*) Extraction of Bismuth from Carbonaceous Ores.

(*b*) The Classen Lignum Co.

(*c*) The Plant of the Kentucky Soda Ash Co.

After the reading of these papers the meeting was adjourned.

Friday Morning Session

June 23, 1911.

Meeting called to order by the President.

The President:

I will first call on the Secretary for some communications.

Secretary Olsen:

I have to announce the death of one of our members and officers of the Institute, Mr. Herbert Hollick. I have prepared a statement of the career of Mr. Hollick to be inserted in the forthcoming volume of Transactions, and I desire to read this statement, and then if the Institute desires to take any further action or pass any resolution with reference to Mr. Hollick it will be free to do so.

The President:

We all deplore very deeply the loss of Herbert Hollick whose death was so early and untimely. I personally have treasured his friendship very much for the short time during which I had the pleasure of knowing him. I worked with him during the first two or three years on the Membership Committee and I found him always an honest and conscientious member of the committee who always wanted the best for the Institute. What action does the Institute desire to take?

Mr. Belden:

I move that the President appoint a committee to draft suitable resolutions.

Motion seconded and unanimously carried.

The PRESIDENT:

I will appoint on this committee Dr. Samuel P. Sadtler, Geo. N. Tyson and Dr. Geo. D. Rosengarten.

We will now proceed to the papers of this morning. The first paper is "Industrial Chemical Calculations" by Prof. Joseph W. Richards.

Secretary Olsen read Prof. Richard's paper.

Secretary OLSEN:

Personally, I should very much like to hear from the members of the Institute as to how much of such calculation is actually done in practice, and practically could or should be done. It is my impression that Prof. Richards has gone to the extreme, and that he has suggested a lot of subjects for calculation that in practice would not be done and need not be done, but I may be entirely wrong in that conclusion.

The PRESIDENT:

Gentlemen, I ask you to express your opinions and discuss this paper particularly in regard to the question Dr. Olsen has just put. A discussion of this paper might develop some opinions which would be of value in our educational campaign this year.

Dr. GUDEMAN:

Prof. Richards not being here I don't believe that we are capable of discussing a paper of that kind intelligently, and I move that the paper be made the subject of discussion at the next meeting.

Prof. JAMES:

I second the motion.

Prof. WITHROW:

I would like to ask if we will have the opportunity of seeing the paper meanwhile?

Secretary OLSEN:

Again, the only way to see it is to publish it. It is a question whether it would be well to publish all these papers. It involves double publication, first without discussion and then with discussion.

Dr. SADTLER:

Mr. Chairman, I think that illustrates a necessity we have met. In some of the other societies, for instance, the American Electro-

Chemical Society, they make a point of asking as many authors of papers as possible to send them in two weeks or three weeks in advance of the meeting. Then, the Secretary has them printed in leaflet form and distributes them. That makes it possible to have discussion. If we only had this paper a week before coming here and had a chance to look it over and read it carefully, I have no doubt a half dozen or more would have come here prepared to discuss the paper intelligently. It is quite obvious we are facing a difficulty. It is impossible not having it read to discuss it intelligently. I think before we have another meeting, before the December meeting, for instance, the intended authors of papers should be asked to send in their papers not less than two weeks, if possible three weeks, before the date of the meeting, and then it would not be an expensive matter for the Secretary to have perhaps one hundred copies of a leaflet of three or four pages printed and distributed to the members, or to such members as desire a copy, and then we can have intelligent discussion. It is very unsatisfactory when we have these meetings to come here and find we can't discuss papers; we can't intelligently appreciate what is presented to us. We would get three times or possibly a dozen times the benefit if we were only in a position to discuss these matters intelligently. Many of us probably have quite positive views about some of these things. We can't help it now as far as this meeting is concerned, but it seems to me before we have another meeting that something ought to be done.

Secretary OLSEN:

Mr. President, I am very certain that on Wednesday we had some men who had very positive views on education and were quite ready to express them, but the opportunity was not given. They were ready to give us a lot of information on the subject, they came for that purpose; and while they had not heard these papers they had their own views to express on the points raised. This paper came in this morning, and it is physically impossible to have reprints ready, unless papers are sent in two or three weeks in advance. In many cases we can't get papers in time for publication; it is simply impossible. Also the expense involved would be quite considerable if all these papers were published beforehand. I am authorized to have papers printed in advance of a meeting by a vote, passed at the last meeting, whenever papers are sent in and the request

made. I don't know what more can be done. If I have the authorization and the papers don't come in, what can be done ?

Dr. GUDEMAN:

That is just the point now. I believe at our next meeting we ought to give time to the discussion of these papers. You take last Wednesday when the second paper was finished it was about twelve o'clock, and we had an excursion at 12.30; now, it wouldn't be doing justice to the people who prepared the papers nor to those who wished to discuss them to cut the time for discussion down to one-half hour for all of them. You haven't the time. I think the Program Committee ought to take that into consideration, and, instead of reading the papers, print them as Dr. Sadtler suggested and submit them to the members before and then have the discussion. I don't believe there is anybody here that on the spur of the moment wants to get up or feels competent to get up and discuss that paper of Dr. Richards'. Certainly it is an important subject, and it is worthy of discussion.

The PRESIDENT:

I understand that you now wish that the discussion of this paper be postponed till the next meeting and that there be included in this motion that this paper should be published in bulletin form so that everybody might be prepared for discussion at that time?

Dr. GUDEMAN:

Well, as I understand, it is necessary to include that in the motion to have it published, but we have a publication committee, a committee on papers, and I believe they ought to have the power to publish them without putting it as a special motion. I don't want to make a motion that compels the committee to publish it irrespective of whether they consider the paper worthy of being published. I think the committee on publication ought to have that authority to publish them before the meeting. I will include it in the motion as it is required, but I don't think that it ought to be done that way.

The PRESIDENT:

I understand from the Secretary that the Publication Committee or the Secretary has the authority to publish it if he deems it necessary, and he certainly will since he has the opinion of the meeting here.

Prof. JAMES:

I think that it logically should go with the papers that were read on Wednesday as it pertains to chemical education.

The PRESIDENT:

I believe it should be printed with them; I believe it belongs there. I will put the motion that the discussion of this paper be postponed till the next meeting.

Motion carried.

The next paper on the program is a paper on the " Rapid Determination of Tin in Food Products " by Dr. Gudeman.

Preliminary to reading the paper on this subject, Dr. Gudeman read a communication from Mrs. Ella Flagg Young in regard to the enrollment in the department of Chemistry in the Chicago evening schools.

Mr. Charles L. Campbell then read the following papers:

Distillation on the Continuous System.

A New System of Lead and Silver Lining for Chemical Apparatus.

Announcements were then made by the Secretary in regard to the entertainment program.

Mr. Jordan of Indianapolis extended a cordial invitation to the American Institute of Chemical Engineers to attend the convention of the American Chemical Society, after which the meeting adjourned.

FRIDAY EVENING SESSION

June 23, 1911.

Meeting was called to order by the President.

The PRESIDENT:

We will now have the paper which was left over from this morning by Dr. William M. Grosvenor on " The Institute and the United States Patent System.

In the absence of Dr. Grosvenor the Secretary read his paper.

Secretary OLSEN:

We have a communication with reference to this subject from L. Gutmann, which was read.*

* This communication, together with Dr. Grosvenor's paper and the discussion, will be found on page 417.

Dr. GUDEMAN:

To bring the entire matter directly before the Institute, I move that we endorse the resolution prepared by Mr. Gutmann of St. Louis.

The PRESIDENT:

Gentlemen, you have heard the motion. Is it seconded?

Mr. WITHROW:

I second the motion.

Dr. SADTLER:

Would it be well to amend the motion and provide for the appointment of a committee to prepare resolutions along the same line. I think Dr. Grosvenor ought to have a chance to co-operate in the presentation of our expression because he has gone to the trouble of reviewing the whole subject. I think it would be well to appoint a committee, and have Dr. Grosvenor on that committee. We could present a more general and fuller expression of opinion covering a wider range of subjects. Having had this paper I think we ought to go into the subject a little more deeply than merely pass a formal endorsement. I think we ought to do this in a manner that will reflect credit on us.

Dr. GUDEMAN:

Mr. Chairman, I will withdraw my motion if it is satisfactory to the seconder, and give Dr. Sadtler an opportunity to present his views in the form of a motion.

The PRESIDENT:

Dr. Sadtler, will you formulate your views in a motion?

Dr. SADTLER:

I move that the President be authorized to appoint a committee from this Institute, recognizing Dr. Grosvenor, who has worked on the matter already, to prepare an expression of our views in regard to the recognized evils of the present patent practice. Its evils are not simply one but several. I think we ought to cover several at the same time, and then this action could be communicated to the other societies and also sent to President Taft.

The PRESIDENT:

How many members would you suggest be placed on this committee?

Dr. SADTLER:

Three would be enough.

Dr. GUDEMAN:

I second the motion.

Motion unanimously carried.

The PRESIDENT:

I will appoint on this committee Dr. Wm. M. Grosvenor, chairman, Dr. Edw. Gudeman, and Dr. Sam. P. Sadtler.

"The Practical Value of Calorific Tests on Anthracite Coal," by S. F. Peckham, is the next paper which we will now have read.

Secretary Olsen read the paper.

The PRESIDENT:

I invite discussion on this paper. If there is no discussion, we have one other paper "Two Methods of Testing Asphalt," by S. F. Peckham, but the time is passing, and we have some business to attend to, and if it is not the special desire of those present to have it read we could read that paper by title. Hearing no objection, the paper will be read by title.

We will now have the final business session. Has the Secretary any communications?

Secretary OLSEN:

The first matter of business is the expression of opinion by the members as to the place for holding the next meeting. The Committee on Meetings suggests Baltimore and Washington or Boston for the winter meeting, but believe that Boston is most suitable for a summer meeting, while Baltimore and Washington are most suitable for a winter meeting. An expression of opinion is desired. The custom in the past has been to leave the final decision with the Committee on Meetings. One other matter, of course, should be taken into consideration, and that is that next summer will be the meeting of the Congress of Applied Chemistry in New York in September, and it might be desirable to select the meeting place in view of that meeting.

The PRESIDENT:

Has anyone an expression of opinion on the report of the committee? It has been stated to me in private conversation that perhaps Washington would be the most suitable place for the winter meeting

provided at the same time one day's excursion could be made to Baltimore to take in what there is to be seen in Baltimore. It has been pointed out that Washington has a great many collections like the United States Bureau of Standards, and others, which would certainly interest the members very much. The hotels in Washington are of such dimensions that our society easily can be accommodated. One other suggestion has been made—to make Baltimore the headquarters and take an excursion to Washington.

Dr. ROSENGARTEN:

Mr. President, I would move you that the committee take this matter in charge and decide where to meet with the suggestion that Washington be chosen as the next meeting place, and that it is desirable to make an excursion to Baltimore.

Prof. JAMES:

I second the motion.

Motion carried.

The PRESIDENT:

We will now have the report of the Special Committee on Local Committees.

Dr. SADTLER:

The committee appointed Wednesday met with regard to the matter of appointing sub-committees or local committees and has the following to report:

Whereas, it appears desirable that the membership of the American Institute of Chemical Engineers be materially increased, and,

Whereas, it is evident that a considerable number of chemists and chemical engineers would apply for membership, if the objects of the Institute were brought to their notice.

Be it resolved that the President of the Institute be and is hereby authorized to appoint in the larger centers of chemical industries a committee of one or more members, whose business it shall be to ascertain the names of such chemists and chemical engineers, residing in their respective districts, as in their opinion appear qualified and desirable as members of the Institute. Its further business shall be after personal conference with the prospective candidates to prepare a list of such proposed new members and submit it to the Committee on Membership, whereupon this committee shall extend an invitation to these parties to become members of the Institute,

provided their qualifications prove satisfactory to the Committee on Membership.

T. B. WAGNER,
Chairman.
SAM. P. SADTLER,
EDW. GUDEMAN.

The PRESIDENT:

Gentlemen, you have heard the report of this committee. What is your pleasure in regard to this report?

Dr. ROSENGARTEN:

I move that the report be accepted.

Prof. WITHROW:

I second the motion.

Motion carried.

The PRESIDENT:

The Treasurer's report will now be read.

REPORT OF TREASURER FROM DEC. 9, 1910, TO JUNE 15, 1911

CASH ACCOUNT

RECEIVED		PAID	
Ex-Treasurer	$1209.49	Institute badges	$183.39
Institute badges	229.50	Bulletins	247.85
New York Meeting	368.50	New York Meeting	402.82
Current Medal Fund	110.00	Printing	74.76
Permanent Medal Fund	100.00	Reprints	132.53
Reprints	8.00	Secretary's office, expenses	241.64
Transactions, Vol. I	159.00	Secretary's Honorarium	450.00
Transactions, Vol. II	150.00	Transactions, Vol. I	3.39
Dues from members	1672.50	Transactions, Vol. II	1104.90
		Treasurer's office, expenses	25.32
	$4006.99		$2866.60
		In bank	$1015.26
		Certificate of deposit	100.00
		On hand	25.13
	$4006.99		$4006.99

INSTITUTE BADGES

Paid for badges, shipping, etc.	$183.39	Received from members	$229.50

BULLETINS

Bulletin, February, 1910	$58.75
Bulletin, July, 1910	101.51
Bulletin, December, 1910	87.59
	$247.85

THIRD ANNUAL MEETING

New York City, December 7th to 10th, 1910

Expenses	$402.82	Receipts	$368.50

TREASURER'S OFFICE

Postage and printing	$25.32

CURRENT MEDAL FUND

Contributions: Eugene Haanel	$ 5.00	
G. D. Rosengarten	25.00	
A. Lundteigen	5.00	
L. Veillon	5.00	
S. P. Sadtler	10.00	
H. M. Kaufman	25.00	
Edw. Hart	10.00	
T. B. Wagner	25.00	$110.00

PERMANENT MEDAL FUND

International Acheson Graphite Company	$100.00

SECRETARY'S OFFICE

Postage, printing, etc	$241.64	
Honorarium, July to December, 1910	200.00	
Honorarium, January to May, 1911	250.00	$694.64

TRANSACTIONS, VOL. I

Sales	$159.00	Box for plates and express	$3.39

TRANSACTIONS, VOL. II

Sales	$150.00	Publication and express	$1104.90

AUTHOR'S REPRINTS

Paid D. Van Nostrand Co	$132.53	Received from member	$8.00

MISCELLANEOUS PRINTING

List of members	$30.50	
1000 envelopes	2.90	
4000 letter-heads	17.50	
1000 envelopes	3.48	
Application blanks and envelopes	20.38	$74.76

Respectfully submitted,

H. S. RENAUD,
Treasurer.

NEW YORK CITY, June 15, 1911.

The PRESIDENT:

There is a report of the Committee on Monograms and Catalogues. Our Secretary, Dr. Olsen, has a verbal report to make in that regard. Dr. Grosvenor is the chairman of that committee.

Secretary OLSEN:

The Committee on Monographs and Catalogues was instructed to arrange with manufacturers and have the cuts of pieces of apparatus printed in sets of uniform size with a heading "American Institute of Chemical Engineers" and have these sent to members so that by proper loose-leaf binding the members could file them away, and if it was desirable to buy a pump or a still or some other piece of apparatus they would have on file the important types of this apparatus which are on the market, with a more or less authoritative description of the efficiency and capacity and size, and so forth, of the pieces of apparatus in question. The committee was very active until within the last six months when their activity suddenly ceased. I asked the chairman, Dr. Grosvenor, what was the matter. "Well," he said, "I am so extremely busy myself that I haven't had time to work on it," but he promised to take it up actively again. I imagined some of his inactivity was possibly due to the thought that such a catalogue was not called for; that is, that members didn't seem to indicate any great interest in it, and I believe that an expression of interest in the matter and a desire on the part of the Institute to have the work carried on would do something to stir up the committee to activity. It is a matter which may involve some expense for the paper and the dies for the headings. Part of the cost may be borne by the manufacturers, but in any case the sheets must be examined and mailed to members so that, if carried out, it will involve considerable expense and a great deal of labor. If the Institute feels that it is worth while going ahead I think a committee can be appointed of men who are interested and active so that the work can be carried on. I notice one member of the committee is present, Mr. Gibbs. I don't know how much he has done in that line or how he feels in regard to the matter.

Mr. GIBBS:

I am afraid I haven't done anything except to send a few addresses to Dr. Grosvenor relating to catalogues.

Secretary OLSEN:

Do you feel that the catalogue is important and should be prepared?

Mr. GIBBS:

Yes, I should think it ought to be done.

Mr. BROWN:

Is it the understanding that when these catalogues are gotten out anyone can buy them?

Secretary OLSEN:

The opinion was expressed that it should be confined to members, and then it would be a good policy, because it would be something which would draw members. The fact that only members could get a copy of the catalogue would cause a great many to become members.

Mr. BELDEN:

Is there any provision for keeping it up to date?

Secretary OLSEN:

The idea was if any manufacturer developed a new piece of apparatus or modified or improved an old one the sheet should be reprinted and should be sent out to members. The old one could be taken out, being a loose-leaf, and the new one inserted. The idea was that manufacturers would be willing to bear the expense of printing as a part of their advertising, as well as to furnish the cuts, and so forth.

The PRESIDENT:

Will you give us an idea of the amount of work already accomplished?

Secretary OLSEN:

Dr. Grosvenor sent out letters to some thirty-five or forty manufacturers and about half of them consented to co-operate. It is now necessary to prepare the sheets and arrange with the manufacturers who have agreed to carry on the work to have it done.

The PRESIDENT:

Could you give us any idea of the amount of money that would be necessary?

Secretary OLSEN:

There was an authorization of $50 made. That would be a slight beginning; it wouldn't do very much.

Mr. GIBBS:

Dr. Grosvenor was going to appoint different men to take up different parts of the catalogue, I think. I sent him my name and asked him for the electrical apparatus, but we didn't get any further; they didn't decide whether they would go ahead or not.

Mr. BELDEN:

Would it not put the Institute in the position of more or less recommending anything in the catalogue?

The PRESIDENT:

I believe it was intended to aid members of the Institute in case they wished to make any purchase for their own use.

Mr. BELDEN:

What assurance would they have that the manufacturers represented there would be the best in that line?

The PRESIDENT:

I understand it was intended to have a catalogue of all machinery in this special line and leave it to the member who was interested in a certain line of machinery to select what he wanted.

Mr. GIBBS:

Mr. Meade was going to take the pulverizing machinery; he was going to select the names of the best makers and look after that part of it. Similarly, other members who are specialists in different lines were to take their part and select the best makers and place their names in the catalogue.

Dr. ROSENGARTEN:

I can readily realize that such a catalogue would be very valuable, but from my limited experience with chemical manufacture I don't see how you would ever finish a catalogue like that, because there is always new machinery coming in. It covers such a tremendously large field that it is an immense work to undertake, and I believe that every chemical engineer after ten years' experience knows very well where to obtain such-and-such machinery.

Mr. BELDEN:

I think a catalogue showing what the different members are interested in would be of a great deal more benefit than this catalogue. For instance, if Mr. Meade has had particular experience in grinding apparatus the catalogue could state that when we wanted to find out about that kind of machinery that Mr. Meade is more fitted to give satisfactory information than any other member, and it would be easy to write to him, and he being experienced in that line would naturally be acquainted with the latest improvements, and that would certainly be better than this catalogue.

I move that the committee be dismissed and that the society rescind its action.

Dr. GUDEMAN:

I second that motion. I would like to say that every time any society gets out a new report giving a list of its members that I get from one hundred to two hundred and fifty catalogues if I am a member of that society. I don't believe that there is any concern in the United States to-day that doesn't keep track of the different societies and send their catalogues to those they think are interested in it. On that account I second the motion.

The PRESIDENT:

You have heard the motion. This motion is open for discussion. If there is no discussion I will put it to a vote. All those in favor please signify by saying Aye; Opposed, No.

(Rising vote called for).

Upon a rising vote being taken and the votes counted there were four for and four against, the President deciding the vote by voting in favor of dismissing the committee.

Dr. SADTLER:

Mr. President, if there are no other important matters I desire to perform a very pleasant duty, that is propose a vote of thanks. I would move that the thanks of the American Institute of Chemical Engineers be tendered to a number of persons, first of all to the gentleman who represented the Mayor in the address of welcome, Mr. Edward Wade; especially to the local committee and to the individual members, Mr. Bement, Mr. Brooks, Dr. Linder, Dr. Wagner and Dr. Gudeman; to Swift & Company for their courtesy in throwing open their place to us, and to Dr. Richardson, their

chemist; to the Corn Products Refining Company for their courtesy at the Argo plant; to the superintendent of the Dearborn Drug & Chemical Co. and also to Mr. Converse for the courtesy of the automobile ride given the members of the Institute; the By-products Coke Company, Mr. W. R. Knapp; the Carter White Lead Co.; the Indiana Steel Co.; the Universal Portland Cement Co.; the Illinois Steel Co., and to the Standard Oil Refinery at Whiting, for the courtesy which they have offered the Institute. If I have omitted any I would be glad to know because we want to do justice to everybody.

The PRESIDENT:

Gentlemen, you have heard the resolutions. Are they seconded?

Mr. BELDEN:

I second the resolutions.

Motion unanimously carried.

The PRESIDENT:

I believe there is no other business, and a motion to adjourn would be in order.

Dr. ROSENGARTEN:

I move that we adjourn.

Dr. GUDEMAN:

I second the motion.

Motion carried.

And thereupon the meeting adjourned.

THE DINNER

On Thursday evening a subscription dinner was given at the Congress Hotel. Dr. Edward Gudeman, of Chicago, acted as toastmaster and kept the company in the best of humor. The first speaker was President Frerichs, who spoke as follows:

By a singular coincidence we are here assembled at the third anniversary of that memorable twenty-second day of June, nineteen hundred and eight, on which day the founders of our Institute met at Philadelphia to organize, to adopt a constitution and to elect officers for the first year. Only forty in number, they felt by no means certain that they would be able to bring the new organization

to a successful existence. The organization of a new society was not looked upon with favor and some of the existing societies took a stand decidedly adverse to its aims. But our charter members, headed by their able officers, worked faithfully and judiciously in their committees, and supported by a steadily increasing membership of the highest standard, built up an unequaled organization of its kind, as we have it to-day.

In five semi-annual conventions, a large number of valuable papers were presented and discussions were inaugurated, which already begin to bear splendid fruit, reflecting credit upon the Institute. Suggesting improvements on existing conditions, we have earned recognition in our profession. By our discussions on education, the field of the Chemical Engineer was more clearly defined, and we have set to thinking the men who are in charge of those institutions of learning, to whom we look for the education of our future members.

What has been suggested is being earnestly considered and I have no doubt that in a reasonable time courses will be established at some of our universities, which will be eagerly sought by prospective chemical engineers.

By the foundation of an Institute medal for the best contribution to literature in applied chemistry, practical research was encouraged. By your generosity non-members may compete for this medal which, no doubt, will become an incentive to engage in industrial research.

Our committees have taken leading positions in their lines and quite a number of our members have taken active and painstaking interest in establishing regulations for the safe transportation of dangerous articles.

There is a movement on foot to interest all the engineering societies of our country (about 150 in number) for the purpose of bringing about improvement in patent legislation and the establishment of patent courts, and in to-morrow's session you will have an opportunity to define your position toward such a movement.

Our activities have become manifold. They would seem, however, to constitute only a small fraction, of what is to be done for the further development of our profession, and we can only hope, that the good beginning will be an incentive for future work.

But above all the splendid achievements, we treasure the friendships, which have resulted from our common work, and from the social intercourse at our meetings and these friendships would seem to

secure, more than anything else, the continued growth and influence of the A.I.C.E.

Mr. A. Bement, Dr. Geo. A. Rosengarten, Secretary Olsen and Prof. A. H. White also gave toasts.

AWARD OF THE INSTITUTE MEDAL

The most interesting feature of the dinner was the award of the Institute's medal to Mr. F. J. Wood, of Marx & Rawolle, for his paper on "The Multiple Effect Distillation of Glycerine," which was published in Vol. II, of the Transactions. The process is remarkably economical in coal consumption, ease of control and operation as well as purity of product. It is in operation at the Brooklyn plant of Marx & Rawolle as well as in Toronto, Canada, and in England.

In presenting the medal President Frerichs spoke as follows:

Members of the A.I.C.E., Gentlemen:

The American Institute of Chemical Engineers, in New York City, in annual convention assembled, has voted to award from time to time a gold medal to the author of the best original contribution to the literature of applied chemistry, such contribution to be presented only to the A.I.C.E. For this medal members and non-members may compete, and the award is made upon recommendation of our Committee on Publications, of which Prof. Wm. P. Mason of the Rensselaer Polytechnic Institute in Troy, N. Y., is the Chairman for the present year.

It is my great privilege and my pleasant duty on the occasion of this banquet to make the first announcement of this award.

The work of selecting the best paper from those offered in the first three years of the Institute's existence has not been easy, since there were many excellent contributions, which are embodied in three splendid volumes of our Transactions. But there is one contribution, which would seem to attract our attention more than any other paper, since it describes an entirely new achievement, not in Chemistry, but in Chemical Engineering, an achievement, which refers to one of the great general operations most commonly used in our great chemical industries.

Improvements in the operations would seem to rank equal with the discovery of new chemical reactions and in many instances

an improvement in an operation counts more towards making a process profitable, than anything else. The operation of filtering has been facilitated enormously by the invention of filter presses, which were almost unknown fifty years ago. The extraction of oil from seeds has become possible by hydraulic presses, and in the operation of concentrating solutions, the use of multiple effect apparatus has reduced the consumption of fuel to the smallest possible amount. For the operation of drying, I had yesterday the opportunity of showing you the apparatus of F. A. Buehler which dries large quantities of salts in a small fraction of a single minute. Fractional distillation has been perfected to such a degree, that mixtures of liquids, having only slightly different boiling-points, may be separated into their components.

One of the most expensive operations in chemical industry was the distillation with water vapors, which is extensively used for purifying chemicals in all cases, where cheaper operations have failed. The operation is expensive, since large quantities of steam must be generated and condensed to effect the distillation of only a small quantity of the substance to be refined. In all apparatus, used for this operation up to the present time, the heat used for generating steam, and the cooling water for condensing same, was only used once and its cost added to the cost of the product. To conceive the idea of saturating steam with the substance to be refined, and of withdrawing this same substance from the steam without condensing the latter, may well be considered as a new addition to the number of fundamental operations in practical chemistry. *The operation amounts to the use of steam as a solvent and to the crystallization of liquids from such solutions.* An application of this idea has been presented to us by Mr. F. J. Wood.

Mr. Wood does not claim to be a chemist and I understand he is not a college man. He has worked his way up from the ranks. But his great initiative, his ability to concentrate his mind upon one problem and his perseverance in following up his idea, after it was conceived, has put him in the ranks of true chemical engineers, and has made him accomplish an end, of which he well may be proud.

Mr. Wood is not a member of our Institute. Nevertheless, by unanimous consent of our Committee, the first medal awarded by the Institute goes to him.

In the name of the Institute I congratulate Mr. Wood for his

successful work, and I assure him, that we would be proud to count him among our members.

THE EXCURSIONS

During the afternoon of June 21st the plant of Swift & Company was inspected. Dr. William D. Richardson gave a brief explanation of the processes used, after luncheon had been served by the company. The entire operation of killing, cutting, curing, smoking and cold storage as well as the soap plant and glycerine refinery were shown.

On Thursday morning, June 22d, by a special car members reached Argo, Ill., for a visit to the large new plant of the Corn Products Refining Company. The very extensive use of concrete in this plant was noted and members were interested to learn how this material would withstand the action of sulphurous acid. All parts of the plant were inspected, including the converters, sugar and starch houses. When the plant is completed it will have a capacity of 100,000 bushels of corn per day. Many of the members spent the entire day at the plant. Others visited the laboratories of the Dearborn Drug and Chemical Works, after which an automobile sight-seeing trip around Chicago's beautiful boulevards and parks was taken.

Friday afternoon, June 23d, the plant of the By-products Coke Corporation at South Deering was visited, while some members visited the works of the Carter White Lead Company at West Pullman.

On Saturday, June 24th, the plant of the Indiana Steel Company at Gary, Ind., was inspected. An inspection car was provided to carry the visitors around this very extensive plant. Aside from its huge size, the most noticeable feature was the clean and orderly appearance of the entire plant. The coke used is produced in Semet-Solvay by-product ovens from which 80 tons of ammonium sulphate are produced daily. The motive power used is largely electrical, produced by 18 3600-kw. generators driven by 34 gas engines using furnace gases. The open-hearth furnaces, of which there are 14, are heated by producer gas. Much interest was shown in the huge electrically driven rolling mill.

Several of the members also visited the Standard Oil Refinery at Whiting, Ind., as well as the Universal Portland Cement Company at Buffington, Ind.

FOURTH ANNUAL MEETING

HELD AT THE NEW WILLARD HOTEL, WASHINGTON, D. C.,
DECEMBER 20 TO 23, 1911

Opening Session

Wednesday, Dec. 20, 1911

The meeting was called to order at 10 o'clock A.M. by the President, Dr. F. W. Frerichs, who delivered an address of welcome to the visiting members of the Institute. He spoke as follows:

ADDRESS OF WELCOME

I welcome you at this, our fourth annual meeting, at the Capital of the United States. Our committee has prepared a splendid program for us and I feel certain that we will have both a profitable and interesting time. Since our last annual convention, the Institute has grown to 163 members and we are rapidly becoming a factor in the chemical profession. We had a profitable summer meeting in Chicago and by your wishes expressed on that occasion, committees were appointed at various cities, to look up eligible men who might become members.

At the National Congress of Conservation of Natural Resources, the Institute was represented, and we are ready to take active part in this movement as soon as engineers have an opportunity to put in their work.

Our educational campaign was continued and we have entered into a new field, by directing our attention to needed reforms in the Patent Office.

Our activities are multiplying as we go on and there is no doubt that the Institute is beginning to contribute its share in shaping the destinies of our profession, filling its place more quickly and more creditably than we dared to hope when we set out three and one-half years ago.

I congratulate you on the successes which already are yours, I feel certain that they will inspire you to continued efforts and there is no doubt in my mind that still greater achievements will be realized for the benefit of our profession and our Commonwealth.

President FRERICHS:

The first order of business is the canvassing of the ballots for our new officers. I will appoint the following committee for this purpose, viz.:

George P. Adamson, Chairman; Dr. M. H. Ittner, H. F. Brown.

The next order of business is the Report of Officers and the Council.

Secretary John C. Olsen read his report, as follows:

REPORT OF THE SECRETARY

Most of the activities of the Institute are carried on through the office of the Secretary. The magnitude of the general business of the Institute is shown by the fact that about 7000 pieces of mail matter were sent out during the past year. This consisted of circular letters to the members and committees, correspondence with reference to membership and the activities of the various committees, programs of meetings, etc. The Secretary endeavors to keep in touch with the work of all the committees, but more especially with that of the Committee on Membership and the Committee on Publication.

During the year certificates of membership have been prepared and sent to all members and in the future new members will receive certificates within a reasonable time after election. No certificate has been prepared for junior members.

Preparations have been made for a more active campaign for members by printing a small folder giving the objects of the organization of the Institute and its activities. The total membership at present is 1 honorary member, 146 active and 16 junior members, making a total of 163. Thirty active and 10 junior members have been elected during the year, and 3 active and 1 junior member have resigned and 1 active member died, making a net gain of 26 active and 9 junior members.

The publications of the Institute require a great deal of the time of the Secretary. Two bulletins have been issued since our last meeting, namely, that of December, 1910, of 30 pages, containing

the Report of the Committee on Chemical Engineering Education and papers on this subject by Dr. Fred. Atkinson, Prof. M. C. Whitaker and Dr. Sabin, and a Questionnaire on Education; also the Bulletin of October, 1911, of 40 pages containing the Report of the Committee on Chemical Engineering Education and papers on this subject by Professors James and Withrow.

The third volume of our Transactions containing 410 pages was issued during September. Besides the reports of Officers and Committees and the meetings of the Institute, 26 papers were published in this volume. A growth of about 33⅓ per cent was shown over Volume II.

It would undoubtedly be desirable to insure an earlier issue of our Transactions. The prime cause of the late issue is due to the fact that few of our members are ready to hand to the Secretary copy of papers read at the time of delivery. In many cases six months elapses before copy of papers is sent to the Secretary. Only about half of the papers for Volume III were ready for the printer in February, 5 more were ready in March and 5 more in April, and the last paper was received on May 1st. This brought the preparation of the index to the busy month of June when the summer meeting was held and the printing and binding of the volume during the later summer months when printers and binders are rushed with work for the fall trade. The increased size of volumes also requires more time for setting type, corrections and printing. It will, no doubt, be necessary to adopt fixed dates for the final delivery of papers for the Transactions.

J. C. OLSEN,
Secretary.

The SECRETARY:

The Report of the Committee on Publications has not been prepared separately from this Report of the Secretary, but is included in it.

The PRESIDENT:

You have heard the Secretary's Report. Are there any remarks?

Dr. A. C. LANGMUIR:

As a member of the Membership Committee, and one who has come quite closely in contact with Dr. Olsen's work as Secretary, I want to emphasize and call the attention of our members to the splendid work which Dr. Olsen is doing, and the large amount of time which he is voluntarily giving to the cause of the advancement

of the American Institute of Chemical Engineers, and I think we owe him a tremendous vote of thanks for the work he is doing and has done in the past, and I so move you.

The motion was seconded and carried unanimously.

The PRESIDENT:

In the name of the American Institute of Chemical Engineers, I extend thanks to Dr. Olsen which he so fully deserves.

Dr. OLSEN:

I thank you, gentlemen, for this expression of confidence and appreciation. It is worth a great deal to me to feel that the work is appreciated.

The PRESIDENT:

What is your pleasure with regard to the Secretary's Report?

On motion the Report of the Secretary was adopted unanimously.

The PRESIDENT:

The next report is that of the Committee on Meetings.

Dr. WM. M. GROSVENOR:

The only report that the Committee has to make is the program, which must speak for itself.

The PRESIDENT:

The next report is that of the Membership Committee.

The report of the Membership Committee was read by the Secretary, as follows:

REPORT OF THE MEMBERSHIP COMMITTEE

Three meetings of the committee have been held since the semi-annual meeting in Chicago. Twenty-six applications have been received during the half year. Adding the number received during the first half of the year (31) makes a total of 57 applications received during the year, 41 of which were for active membership and 16 for junior membership. Fifteen have been rejected.

Of the 26 applications received during the past six months, 19 have been acted upon as follows: 9 were recommended for election to active membership and 10 were recommended for election to junior membership. Four of the candidates recommended for election to junior membership had applied for election to active membership.

One of these refused to accept junior membership, considering himself qualified for active membership. In a number of cases, men who apply for information and find themselves qualified only for junior membership, prefer to wait until they can be elected to active membership. The Committee carefully considers the education and training of candidates for junior membership so that when the required amount of experience has been obtained, they can be admitted to full membership. In case of doubt as to a candidate having the full qualifications for active membership, the committee finds it very convenient to recommend for election to the lower grade so that in practice the existence of this lower grade serves to raise the standards of full membership instead of lowering them as was feared by some of our members.

Three Institute ballots for membership have been taken and canvassed with the result that the 10 candidates for active membership and 4 candidates for junior membership on these ballots were elected, no candidate being rejected.

The Committee also considered and approved for publication a small folder giving a sketch of the organization and work of the Institute to be used in securing new members.

Respectfully submitted,
A. C. LANGMUIR.

On motion, duly seconded, the report was adopted unanimously.

The PRESIDENT:

There is one other committee, that appointed to draw up resolutions with regard to the premature death of one of our members.

Dr. George D. Rosengarten, chairman, presented the following resolution:

"Whereas, the American Institute of Chemical Engineers has suffered a great loss in the death of one of its most faithful and earnest members, Herbert Hollick, of Camden, N. J., therefore, be it

"Resolved, That we place on record our deep appreciation of his sterling worth and devotion to this Institute, and

"Resolved, That we mourn his death as the loss of a warm friend and one whose work and worth as a man and fellow worker will live long in our memories.

"SAMUEL P. SADTLER,
"GEORGE N. TYSON,
"GEORGE D. ROSENGARTEN."

The PRESIDENT:

I myself may add a few words to this resolution. Mr. Hollick was one of those members of our Society with whom I worked gladly in the first year on the Membership Committee, and I personally treasure the goodwill, the friendship and fairness of this deceased member. I appreciate the friendship of any man of that kind, and I gladly join in the expressions of gratitude which have been given in this resolution. I would suggest that we adopt this resolution by a rising vote.

The resolution was adopted by a rising vote, all of the members standing.

The Secretary read the following communication:

" The Officers and Members of the Executive Committee of the Eighth International Congress of Applied Chemistry have the honor to invite American Institute of Chemical Engineers to join the Congress and to take part in its proceedings.

" The opening meeting will be held in Washington on Wednesday, September 4, 1912, and the subsequent meetings in the City of New York; closing on Friday, September 13th.

" Please send reply to Dr. Bernard C. Hesse, Secretary, 25 Broad Street, New York."

The SECRETARY:

On instruction from the officers of the Institute, I have replied, accepting this invitation of co-operation with the Congress next September.

The PRESIDENT:

One other matter to be brought to the attention of this Institute relates to the next meeting, whether the Institute shall postpone the summer meeting until the time that this Congress meets, or whether we shall have a special summer meeting. I call for views on this subject.

A MEMBER:

I understand that all the other Societies have given up the idea of holding any summer meeting and propose to merge their meetings with that of the International Congress of Applied Chemistry, and I think we should fall in line.

Dr. MCKENNA:

Are there not some difficulties with regard to the presentation of papers? I was speaking to Secretary Hesse of the Congress

with regard to this matter recently, and he thought that all of our papers should be presented to the Congress, but I have not heard of any definite mode by which it can be done except by announcement, participation and subsequent publication. There seems to be indefiniteness about it and therefore I suggest the consideration of the subject of an independent meeting.

A MEMBER:

What would be the effect upon our next volume of our participation and presentation of the papers of this Institute at the Congress of Applied Chemistry? If we had only a business session, and all the papers were to go for presentation to the Congress of Applied Chemistry, would we have any rights in these papers for independent publication, or would we have to cut out that much material from our next volume?

The SECRETARY:

As I understand it, the Congress reserves the right to publish all papers presented first, and that no other body shall publish them before they do. But if they fail to publish papers before the 31st of December, then such papers may be published elsewhere; and if they publish before the 31st of December, they may also be published elsewhere after December 31st. So my understanding is that if any papers were read by our members, they could be published in our next succeeding volume, as our volume does not come out until after the 31st of December. That is the way I understand the matter, but I believe we would have less papers if we joined in the Congress and omitted the summer meeting. I believe, likewise, when we have a meeting a good many papers are presented that otherwise would not be, and undoubtedly it would cause considerable shrinkage in our publication.

A MEMBER:

I know that Secretary Hesse intends to publish 24 volumes, aggregating 25,000 pages, to include all papers received before the first of July. I presume all papers presented to the Congress will be received by that time.

Dr. BAEKELAND:

I happen to be on the Executive Committee of the International Congress of Applied Chemistry, and I beg to change the impression which has prevailed until now. At the last meeting it was decided

to change the rules with regard to the publication of the papers of the International Congress. Very important modifications have been made and you will be notified that the only requirement for papers to be presented before the International Congress is that they shall not be published before they are read; afterwards they can be published. Restriction with regard to the publication of papers does not hold good any more, except that they should be previously read before the International Congress.

Now with regard to the International Congress, let us not forget that probably another such event will not occur a second time while we are alive, and the Societies of the United States can very well afford, for half of the year, to subordinate their work to that of the International Congress, which gives a very good opportunity for all to co-operate in our own sphere, and I believe it will be a very good example to join with the other Societies in having a joint meeting of the Congress, and limit our private meetings to simply a business meeting.

Dr. LANGMUIR:

I think it will be a very difficult matter for the Program Committee to arrange an interesting meeting next summer, and that we will not get many papers unless we join with the International Congress.

A MEMBER:

I agree with Dr. Langmuir. I believe if we do not join with the International Congress we will not get many papers.

Prof. WHITAKER:

In answer to Dr. McKenna's question, I might say that the natural course by which papers are to be presented by this Society would be to present them to some of the Sections of the Congress as now organized. I believe the Chairmen of the Conventions are scouring the country considerably. In some of our editorial work we notice a falling off in contributions and the excuse is that they are being held back for the International Congress.

There is another feature I think we should consider, and that is, that the Congress is organizing a large number of excursions of various sizes and durations to visit the industrial plants throughout the country as far west as California, and as far south as the City of Mexico, and those excursions will be organized in laps, so that one can get an excursion of as long duration and over as large a territory as he likes. Permission is being given to enter plants which

would not otherwise be thrown open, and it seems to me it is an opportunity which this Institute will never have again, by joining with the Congress in these meetings, of visiting plants which have never been visited before, and I think we should seriously consider giving up our summer meetings and join with the Congress.

The SECRETARY:

If we do that, would our Committee on Meetings conduct a campaign to secure papers, these papers to be published in our Transactions when the time came, as well as in that of the Congress? Would it be understood that our members would prepare papers to be inserted in our Transactions?

Prof. WHITAKER:

There have been a number of attempts to break in on the existing organization of the Congress, and that makes the situation rather difficult sometimes to handle, but I believe if our organization would get in touch with the proper men in their organization it could be worked out very easily, so that we would reserve the right to use the papers as we saw fit in our meetings. They are not anxious to pad the proceedings with papers of ancient vintage, as has been done in previous Congresses, but they reserve the right to publish them as original papers, and after that the Societies can do as they please with them.

Dr. MCKENNA:

I make a motion that the next formal meeting of the Institute be held in New York City, and be confined to the necessary business of the Institute, and that the presentation of papers offered to the Meetings Committee or the Secretary by members of this Institute be accepted and handed to the Secretary of the Congress.

The motion was duly seconded and carried unanimously.

The PRESIDENT:

To make up our time, we will not wait for the report of the Committee on ballots, but communicate that to you as soon as they are ready, and we will proceed with our papers. We have quite a number of them this morning.

Dr. Chas. F. McKenna then read before the Institute the following paper:

The Hardening Process in Cements and Plasters and a Chronographic Apparatus for Recording Set.

The PRESIDENT:

Gentlemen, you have expressed your thanks already to Dr. McKenna for this paper by your applause, and it is not necessary for me to add any thing more.

Now with the permission of the two following speakers on the program, I would like to ask Mr. Clarence Hall, Expert in Charge of the Explosives Section, Bureau of Mines, Pittsburgh, Pa., who has just come in, to present his paper on Advances in Testing Explosives, and for your information I would like to say that the papers of Mr. L. S. Hughes and Mr. Ludwig Thiele are here, but the gentlemen are not, so they will be read by the Secretary.

The following papers were then read and discussed:

Distribution of Power in Portland Cement Manufacture, by Richard K. Meade.

Some problems in the Manufacture of C. P. Acids, by J. T. Baker.

The Manufacture of Gelatine, by Ludwig Thiele.

The Combustion of Pulverized Fuel, by L. S. Hughes.

The PRESIDENT:

We will now receive the report of the Committee on the canvass of ballots for the election of officers for the ensuing year.

Mr. George P. Adamson, Chairman of the Committee, presented its report as follows:

	Total number of votes cast	92
	Void because unsigned	4
For President:	Leo H. Baekeland	85
	Jos. H. James	1
For 3d Vice-President:	M. C. Whitaker.	87
For Secretary:	John C. Olsen	87
For Treasurer:	H. Dannenbaum	39
	H. S. Renaud	43
For Auditor:	G. W. Thompson	82
For Directors:	A. C. Langmuir	59
	H. S. Miner	50
	A. Bement	45
	T. B. Wagner	45
	T. J. Parker	42

GEO. P. ADAMSON, *Chairman.*
MARTIN H. ITTNER,
H. F. BROWN.

The President then announced that as a result of the balloting the following were declared elected as officers for the ensuing year:

President: Leo H. Baekeland.
3d Vice-President: M. C. Whitaker.
Secretary: John C. Olsen.
Treasurer: H. S. Renaud.*
Auditor: G. W. Thompson.
Directors: A. C. Langmuir.
H. S. Miner.

There being a tie vote between Messrs. A. Bement and T. B. Wagner, it was decided that the Secretary decide the tie by preparing slips of paper on which the name of each candidate should be written, and the President should draw the lucky name. This was done and resulted in the selection of Mr. A. Bement as a Director of the Institute.

The PRESIDENT:

I congratulate the newly elected officers, and not less I congratulate the Institute in having made such a good selection. You have now a President who is at the same time a scientific man and a manufacturer, and is the father of a new industry. I think the Institute can run on safely for another year.

Dr. A. C. LANGMUIR:

I desire to bring before the business meeting of the Society, the advisability of our Institute of Chemical Engineers adopting a Code of Ethics. The American Chemical Society has recently taken a great deal of interest in this question. It has been discussed at the Indianapolis meeting, and also at Washington, and I think the question of adopting a Code of Ethics would be an excellent thing to consider. Another question to consider is a Code with regard to practicing chemists and whether we cannot take some action with regard to licensing practitioners of the chemical profession.

Dr. WM. M. GROSVENOR:

I move that the President appoint a committee to take that matter under advisement and report either to the Institute at its next busi-

* Mr. Renaud subsequently resigned the office of Treasurer, to which Dr. F. W. Frerichs was appointed by vote of the Council.

ness meeting, or refer to the individual members by letter at any time. The motion was duly seconded and carried.

The President appointed as the committee empowered to act under the foregoing resolution, the following: Dr. A. C. Langmuir, Dr. Wm. M. Grosvenor, and Dr. Chas. F. McKenna.

On motion the meeting adjourned at 1 o'clock.

Evening Session

Wednesday, Dec. 20, 1911

The Institute reconvened at 8 o'clock, Dr. F. W. Frerichs in the chair.

Address of the retiring President, Dr. F. W. Frerichs.

Some Problems in Chemical Engineering Practice.

(*a*) Manufacture of Chloroform from Alcohol.

(*b*) Construction of Laboratory Apparatus.

(*c*) Manufacture and Testing of Shipping Cylinders for Liquid Ammonia.

Paper by John C. Minor, Jr., Manufacture and Testing of Carbonic Acid Cylinders was then read.

Adjourned at 10:30 P.M.

THIRD DAY

Friday, Dec. 22, 1911

Morning Session

The Institute reconvened at 10:00 A.M., the President, Dr. F. W. Frerichs, in the chair.

The President:

There are one or two things which belong to the business session of the Institute as prescribed by the program, and one of these is the Treasurer's Report, which should have been presented yesterday morning but came in too late.

The Secretary then read the Report of the Treasurer for the year 1911, and on motion, duly seconded, the same was adopted unanimously.

ANNUAL REPORT OF THE TREASURER

Dec. 9, 1910, to Dec. 15, 1911

Receipts

Membership Dues	$2095.00	
Certificates of membership	144.15	
Ex-Treasurer	1209.49	
Institute badges	236.50	
Interest	3.36	
Third Annual Meeting, New York City	368.50	
Third Semi-Annual Meeting, Chicago	95.00	
Current Medal Fund	160.00	
Permanent Medal Fund	100.00	
Reprints	31.00	
Transactions, Vol. I	168.60	
Transactions, Vol. II	165.60	
Transactions, Vol. III	30.00	$4807.20

Disbursements

Bulletins		$247.85	
Institute badges		183.39	
Certificates of Membership		173.60	
Miscellaneous printing		121.18	
Third Annual Meeting, New York		402.82	
Third Semi-Annual Meeting, Chicago		217.06	
Current Medal Fund		2.10	
Author's Reprints		132.53	
Secretary's office:			
Salary	$750.00		
Expenses	341.50	1091.50	
Treasurer's office, Expenses		25.32	
Transactions, Vol. I		3.39	
Transactions Vol. II		1104.90	
Transactions, Vol. III		538.90	
Transactions, Vol. IV		21.16	$4265.70
Cash in bank			$541.50
			$4807.20

New York City, Dec. 15, 1911.

Respectfully submitted,

H. S. Renaud,
Treasurer.

The President announced that by unanimous vote of the Council the office of Second Vice-President, serving for a term of two years, was given to Dr. Theodore B. Wagner, of Chicago, Illinois.

The PRESIDENT:

We now come to the installation of officers for the ensuing year, but before so doing I wish to extend my thanks to the old officers for the kind co-operation by which it has been made possible to conduct the work of the Institute to the satisfaction of all the members. I am particularly happy to be able to introduce officers according to your choice who will be so very much more able to further the interests of the Institute than I have been able to do. They are near New York, while I shall be a thousand miles away.

I now ask Dr. Sadtler and Dr. Grosvenor to conduct our new President, Dr. Leo H. Baekeland, to the chair.

Dr. Baekeland was formally inducted into the office of President of the Institute, and spoke as follows:

Gentlemen, I yesterday had occasion to refer to the choice you made, and I was wondering why you elected me. I thank you for the distinction which you have conferred upon me. Let me consider it more as a manifestation of friendliness than as a distinction of merit. I thank you.

President BAEKELAND:

I understand from the Secretary that there are two Committees which have reports ready to submit. One is the Medal Committee, and the other is the Committee on Ethics of the Chemical Profession.

The Secretary then presented a verbal report of the Committee on Medal, as follows:

REPORT OF COMMITTEE ON MEDAL

The Medal Committee is working on a proper design for the medal, which should have been presented at the Chicago meeting, and an attempt was made to have it ready for this meeting, but without success, the difficulty being that a design had not been submitted which was satisfactory to all the members. The Committee presented last June, at the Chicago meeting, a number of designs and suggestions for designs, but the members present at the Chicago meeting instructed the Committee to secure more designs and submit them.

The designs presented at the Chicago meeting were along two lines: first, to use the bust of some noted Chemical Engineer, and

a number of men were suggested and six months consumed in that discussion, with the result that no man acceptable to the members was found. Then a symbolical design was prepared and submitted. It showed a chemist working in his laboratory, and through the window were seen smokestacks and factories, the idea being to symbolize a chemical engineer working out his process in the laboratory and then transferring it to the plant. The general opinion with regard to that design was that it was too close to the actual and did not have enough of the ideal about it.

The Committee then tried to get some design which was a little more along the ideal line, and secured the assistance of the Whitehead & Hoag Co., of Newark, N. J., and an artist named Henning Rydén, who has done some very excellent work. I have a medal here which he prepared, and it seems to me to be handsomely executed. I submitted it to an artist in whom I have great confidence, a critic of long experience, and without telling him who the artist was, I asked him if it was a good piece of work, and without hesitation he said it was admirably executed; so I concluded that we had found an artist who would give us a good piece of work.

We might spend a good deal of money in getting a very artistic design; we might spend say $300 to $500 on the design and then use material like silver, which would show an artistic design but the material in itself would not be particularly valuable; it would be an artistic rather than an intrinsically valuable medal and in the larger medal which we could produce in silver, it would show off better.

In designing something for us, three ideas have been submitted, in the form of rough sketches which present the idea rather than symbolize what can be done.

The first design shows Chemistry demonstrating his discovery to Industry. The design shows two figures—one representing a working chemist (in any dress you desire) who apparently has produced a new product and is holding it up in his hands. There is a seated figure to his right which symbolizes " Industry." " Industry " is a vigorous, strong, muscular man sitting near his anvil, with some buildings, etc., in the background. Industry is prepared to manufacture the chemist's product.

The second design shows the figure of a chemist in the center, the same figure of " Industry " to the left; but to the right is " Humanity, "represented by a woman with a child, illustrating that

the chemist has developed some new idea of great usefulness to humanity, which will be developed by " Industry."

The third idea which has been suggested has appealed to those of us who have thought of it, the more we thought of it. That idea was to have a central figure, undoubtedly of a woman, to symbolize " Fame," holding in her right hand a laurel wreath, the idea being that " Fame is crowning with a laurel wreath " the chemist who has accomplished something of note. The idea as presented included the busts of famous chemists around the exterior of the medal, but that is not entirely essential. We could have the figure of " Fame " with a laurel wreath, and then " American Institute of Chemical Engineers " around the medal.

These three suggestions are given so that you may decide between the symbolical or allegorical idea, rather than a more realistic idea, such as a man's figure in a laboratory and factory buildings, as was at first suggested.

Dr. F. G. Wiechmann:

I express myself in hearty accord with the suggestions of Professor Olsen. It seems to me the idea of " Fame " crowning the success of the man would appeal most strongly to those of us who have given consideration to the matter, and the more allegorical or symbolical, the better it would be for the purpose.

The President:

If there is no further discussion of the subject of the medal design, we will proceed with the next part of the order of the day, the report of the Chairman of the Committee on Ethics of the Chemical Profession.

Dr. Wm. M. Grosvenor:

Dr. Langmuir is Chairman of the Committee, and I went out to see if I could find him, but not doing so, I will outline briefly, in his place what has been done, because the Committee is not ready to report but possibly will be able to do so to-night.

Some twelve or fourteen points were discussed, and it was decided, in a general sort of way, to present a preamble and conclusion to the section which may become a section of our Constitution, and to outline some of the points which it would seem desirable for us to cover in one way or another, and to present the whole to the Institute for consideration. If it is to be incorporated in our Con-

stitution, where it properly belongs, it will require consideration between now and the next meeting, at which time it should be considered, and it might be desirable to call upon the members for an expression of their views, because such a matter as this is too important to be entered upon hastily. Some of the other Societies have found phrases in the Code of Ethics that were capable of such misconstruction that it was found necessary to change the phraseology, so the Committee thought it best to submit a tentative report this evening and present it to the Society for consideration for six months before final action upon it.

The PRESIDENT:

I think it is desirable that whoever has any good suggestions to make on this subject should make them as briefly as possible. Yesterday Dr. Wiley made some suggestions as to splitting up these organizations. He forgot to mention one very important point, that there is not a single member of this Society who is not at the same time a very devoted member of the American Chemical Society.

Secretary OLSEN:

That is not quite right. We have quite a few members who are not members of the American Chemical Society.

The PRESIDENT:

Well, I believe a very large majority of our members are members of the American Chemical Society, but it has become such an enormous body, it is like a little molecule in the center of a very big table.

The following papers were then read and discussed:

SYMPOSIUM ON THE UNITED STATES PATENT SYSTEM

The United States Patent Office, E. B. Moore, Patent Commissioner, U. S. Patent Office.

Protection of Inventions by Patents. Existing Defects and Remedies Therefor, Walter D. Edmonds, of Edmonds & Peck.

The United States Patent System, R. N. Kenyon, of Kenyon & Kenyon.

Discussion.

Adjourned at 1 P.M.

AFTERNOON SESSION.

The Institute reconvened at 4:45 P.M., the President Dr. Leo. H. Baekeland in the Chair.

A paper on a course in Chemical Engineering Education, prepared in accordance with the vote of the Institute on the Questionnaire of December, 1910, was read by J. C. OLSEN. A protracted discussion followed.

The PRESIDENT:

Before adjourning, Mr. Taylor has a very short report to make about the Conservation Congress.

Mr. Taylor then read his report on the Conservation Congress.

Washington, D. C., December 22, 1911.

Through the appointment of our retiring president, Dr. Frerichs, I attended the Third National Conservation Congress at Kansas City as a delegate from this Institute. Dr. Frerichs also attended.

I will not take your time to report specific doings, but to say that six or eight of our national scientific societies were represented, and welcomed to participate in the transactions. The presence of such representatives is more and more appreciated with each succeeding Congress, and the scientific aspect of conservation is recognized as a directive force. That our Institute may be more perfectly represented as a body, and be able as various occasions may demand to present a consensus of opinion on conservation and on questions of public policy, I desire to move that a Committee on Conservation and Public Policy be appointed. As an example of the usefulness of such a committee it may be cited that in the early part of the present month there was held in Washington a hearing before the National Waterways Commission concerning the development and uses of water power, in which some of our scientific societies participated with helpfulness to the Commission. Such a committee could formulate principles that could be submitted for the action of the Institute and be available for use on similar occasions where it would be effective in influencing legislation, or in case of urgency the Committee itself could act more effectively than a delegate who might be appointed to attend. At no previous time has the legislative department of the Government, both State and national, been more desirous of having disinterested scientific advice on public questions than at present, and it would seem that a committee which

was at some pains to inform itself on questions of public policy would be in line of such usefulness. I would suggest that in case of the appointment of such Committee it is of such importance that it be appointed by the Executive Committee of the Institute at its early convenience.

Respectfully submitted,
EDWARD R. TAYLOR.

It was moved and seconded that a permanent committee be appointed to take up the matter of Conservation, and the motion was carried unanimously.

The PRESIDENT:
How shall the committee be appointed?

Mr. TAYLOR:
I suggest that it be done by our President. That would give an opportunity to study the question. I think it is a matter of some importance, Mr. President.

A MEMBER:
It seems to me that before we adjourn we ought to make some arrangement to handle this educational question and not simply drop it.

Dr. F. W. FRERICHS:
I would suggest that the Committee on Education be continued, or that another committee be appointed for the next year, and that it should be the duty of this Committee on Education to bring all that has been said on the subject of the education of chemical engineers into the form of resolutions, which resolutions might be circulated among our members and submitted to them for letter ballot. The result of such letter ballot, should be submitted to the next meeting of the Institute for final action, and after that be published and submitted to the schools and universities for consideration.

The motion of Dr. Frerichs was duly seconded and carried unanimously.

Adjourned at 6:40 P.M. until 8 P.M. the same evening.

THIRD DAY

Friday, Dec. 22, 1911

Evening Session

The Institute reconvened at 8:00 P.M., the President, Dr. Leo H. Baekeland, in the chair.

F. G. Wheeler delivered an illustrated lecture (with lantern slides), on "The Adaptation of the Centrifugal Pump to Chemical Service."

Dr. Baekeland, being compelled to leave before the close of the meeting, asked Dr. F. W. Frerichs to preside over the remainder of the session in his stead.

The President:

We have heard this very interesting paper and thank Mr. Wheeler very much. I now open the discussion and will be glad to hear any remarks.

F. G. Wheeler:

If you gentlemen can show me how to keep packing in the pump with pressure on the suction, I would be very glad to have suggestions.

The President:

It seems to be an impossible proposition.

If there are no questions, we will go into our last business session, and we have to hear about this Patent legislation.

Dr. Wm. M. Grosvenor, Chairman of the Committee on Patents, presented its report, stating that about 150 societies had been corresponded with, of which about 50 are interested in taking up this movement, if reasonable arrangements can be made to inform them as to what can be done.

Dr. Grosvenor:

The general opinion seems to be, if we undertake to do one thing at a time we will get somewhere; but if we undertake to do so many things along the road, we will not get anywhere. It has been suggested, I believe, that a Committee be appointed by the President to take in hand this situation; to go over the papers which have been presented to us, make arrangements for their publication and distribution in some manner, and take such steps as may properly be

taken to co-ordinate the activities of this Society with those of others; to incite the activities of others who have not begun any movement in this direction; and to centralize the whole thing so as to be effective.

There are plans under consideration for that purpose, and for the present it seems to me all that is perhaps necessary is that we realize that details must, of necessity, be left to the Committee, and merely recognize the importance of the work and stand ready to uphold the hands of the Committee who, it may be, shall be appointed by the incoming President, because it is a great work that we have to do.

The Patent Bar Association and the Patent Law Association of Washington have been at it for years, and have not made any more progress than has been made, largely because of our indifference. I say "our," partly because those men who are working in the field are men in a position to bring the greatest pressure to bear at Washington, whereas the Patent Law Association are so little interested in the outcome except in a broad, general sense of reform. As to that, if we take off the brakes so that the work will be facilitated, if we arrange things so that those who have patents to get can be protected, there will be just as much more work as there is to-day, and the patent lawyers will take a broader view of it; and it is very desirable for us to see that things are brought forward with sufficient pressure so that they will go through.

However, in undertaking this thing, we must make up our minds, that it may take a year to put through the first thing we undertake; but to get a Committee which will co-ordinate the work of the other Associations and use the guiding hand, there is no bigger work and no more fruitful work that the Institute can undertake.

Now if it is the pleasure of the Institute, I move that the President appoint, for the ensuing year, a Committee to take these matters in hand, under his direction, and take such steps as may properly be taken, for the furtherance of this work.

The motion was duly seconded and carried unanimously.

The PRESIDENT:

We now have to hear the report of the Committee on Ethics.

Dr. WM. M. GROSVENOR:

Dr. Langmuir is Chairman of that Committee, and as he had to go back to New York, he asked me to state what the Committee had done.

The Committee has considered a number of aspects, basing its action largely on the ethical standards of the Bar Association, and it seemed advisable that such things as are adopted be made a part of the Constitution, therefore it will be necessary to take some action at present, if any definite action is to be taken within a year. The details of what is acted upon may perhaps be left for discussion by correspondence with the Secretary or the Chairman of that Committee, Dr. Langmuir, and all that it will perhaps be necessary to do to-night will be to resolve that the Committee appointed by the President be empowered to frame certain standards of ethics and submit them to the members of the Institute at some time between this and the next meeting, and that the result of this discussion and any suggestions that may be sent in in critisism of it, shall be framed by that Committee in such form as to be submitted for amendment to the Constitution at the summer meeting; that amendment to be framed by the Council and submitted to the members of the Institute at the fall meeting. It is a particularly fortunate time to submit it, as probably more of the members will be on hand at the International Congress of Applied Chemistry than at any other one time, and it will be a particularly advisable time, because we can then all get together on the matter of ethical standards, because otherwise, after they have been put in force, some men may be of the opinion that the standards ought never to have been adopted, and a law which is not supported by the sense of the Institute will not have the same force that it otherwise would have.

If it is the sense of the meeting, I move you, therefore, that the Committee appointed, of which Dr. Langmuir is Chairman, be empowered to frame what are considered say quite common standards of ethics, to be submitted to the Secretary, and by him to the members for expression of their views and suggestions, with a view to the framing by the Council for submission to the Institute at our next fall meeting, of a definite standard of ethics, for incorporation in our Constitution.

The motion was duly seconded and carried unanimously.

The PRESIDENT:

Since this resolution is a proper amendment to the Constitution, I would like to bring up the question whether it will not be well to name a Committee for the revision of our Constitution and By-Laws, such a committee to be appointed by our new President, and the report

for an amended Constitution to be made at the summer meeting of the Council, so that action shall be taken at the December meeting one year from now.

The SECRETARY:

May I ask, Mr. President, why this involves a change of the Constitution?

The PRESIDENT:

This other motion, if carried, will involve a change of the Constitution.

The SECRETARY:

You mean with reference to a standard of ethics?

The PRESIDENT:

I may leave this out and make this an independent motion, that a Committee be named to revise the Constitution and make recommendation at the summer meeting, so that we can take action a year from now.

The SECRETARY:

I thought this motion was to appoint a committee on professional ethics.

The PRESIDENT:

Yes, a new one. There are many points in the Constitution which do not seem to fit the present conditions and requirements.

The SECRETARY:

I wonder if this Committee on Ethics could not handle the whole situation, and we can leave it to them? If after considering the matter, they find that amendments to the Constitution would be necessary, I should think thay would suggest it.

The PRESIDENT:

In that case they would be empowered to make other amendments to the Constitution.

The SECRETARY:

No, they need not be empowered, because any member can offer amendments to the Constitution, so that Committee is entirely free to offer any amendments they like. It is perfectly open.

The PRESIDENT:

Only it has been mentioned that it might be the duty of this certain Committee to make all these recommendations, so that they can be presented at the summer meeting. The chair cannot put this in the form of a motion.

Prof. BYERS:

Mr. Chairman, is it your desire to make a motion that a Committee be appointed to make suggestions for the revision of the Constitution? If so, I make that motion. The motion was duly seconded and carried, the Secretary answering " no."

The SECRETARY:

I cannot see the necessity of it, for the matter seems to be perfectly open for suggestions. I cannot see the point at all.

Dr. GROSVENOR:

Dr. Olsen, I think perhaps it was the same comment that you and I both made, that it was some possible change that might be made in the phraseology of our Constitution, as meeting some of the emergencies that have arisen.

The SECRETARY:

Would not this same Committee do so?

Dr. GROSVENOR:

The Committee on Ethics might or might not do so, but it was for the purpose of having that matter taken up by some Committee that it was brought up at this time.

The PRESIDENT:

We have another pleasant duty to perform, that of expressing our thanks to all those who have entertained us while in Washington, and I have asked Dr. Grosvenor to present a resolution in this regard.

Dr. GROSVENOR:

I move that the Secretary be instructed to formally convey to those named therein, the following resolution on behalf of the members of this Institute, viz.:

Resolved, that the thanks of the Institute be conveyed to those who have co-operated in making this meeting of the Institute profitable and pleasurable to those in attendance:

To President Taft for receiving the Institute at the White House.

To Messrs. Clarence Hall, Patent Commissioner E. B. Moore, Walter D. Edmonds and R. N. Kenyon for the presentation of valuable papers.

To Admiral N. C. Twining and Commander J. S. S. Holden for the courtesy of arranging the visit to the U. S. Naval Proving Grounds at Indian Head, Md., and showing the visitors the many interesting plants on the grounds.

To Dr. S. W. Stratton and Dr. W. F. Hillebrand and others who rendered the visit to the Bureau of Standards profitable and interesting.

To Commissioner E. B. Moore and to Dr. Hill for showing the workings of the United States Patent Office.

There being no further business, on motion the Institute adjourned *sine die* at 9:40 P.M.

EXCURSIONS

On Wednesday afternoon, December 20th, the Institute visited the Bureau of Standards and inspected the standardization of weights and measures, adjustment of pyrometers, thermometers, pressure gauges and similar instruments, as well as the liquid air apparatus. Everyone was impressed by the very excellent work being done by this important Government Bureau.

On Thursday, December 21st, the Institute visited the United States Naval Proving Grounds at Indian Head, Md. This proved one of the most interesting excursions of the meeting. A small steamer had been chartered to convey the members and their guests to the grounds which were reached at 11 o'clock. Four shots were fired from a twelve-inch gun. The method of loading, testing the pressure developed in the gun and velocity of the bullet were shown and inspected with the greatest of interest.

The plants for contact sulphuric acid, nitric acid, the manufacture of ether, nitration of cellulose, powder presses, recovery drying, as well as the testing of the raw materials and finished product were inspected with the greatest of interest.

On Friday afternoon the United States Patent Office was visited. The deplorable condition at this office on account of congestion and overcrowding due to the failure of the Congress to provide suitable quarters for this most important Government office was evident to all visitors.

A number of members of the Institute visited on Saturday the Steel Plant at Sparrows Point, Baltimore, and the Cement Plant of the Tidewater Portland Cement Co.

The attendance at the meeting was excellent, and general satisfaction expressed at the results accomplished.

THE DINNER

On Thursday evening a subscription dinner was held at the New Willard Hotel. Dr. Chas. F. McKenna acted as toast-master. The retiring president, Dr. F. W. Frerichs, spoke as follows:

ADDRESS OF PRESIDENT FRERICHS

On an occasion like this, where so many prominent men are assembled under the auspices of the A.I.C.E., it may well be fitting to say a word about the Institute and what it stands for.

Three years have elapsed since forty men came together in Philadelphia to declare their independence, cutting loose from traditions and demanding recognition for the manufacturing chemists, for the chemical engineers. Chemistry as a science has developed in this country on European, and especially on German lines. At our universities we had highly trained scientists and excellent textbooks had been published from their pens. We had a flourishing chemical society with a membership of many thousands which, besides trained chemists, included many men who were merely interested in chemical progress. Its large membership enabled this society to publish widespread Journals and it obtained a dominating influence in the profession. Such influence, no doubt, was good in many directions and has promoted in many respects the development of chemical knowledge.

But, being primarily led by professors of universities, who were good speakers, the majority of amateur chemists would follow their lead and support them by their vote. Whatever the leader would say was law, and the idea had become prevalent that a man who was recognized as a scientific chemist commanded the entire field of chemical knowledge. Men of science would exert their influence as experts in the courts and cases of manufacturers would be decided by testimony given by men who had specialized in scientific research. Many able manufacturing chemists were members of the society

but their votes counted no more than the vote of an amateur. The manufacturer, as a rule, not being a good speaker, left the field to those in the lead. But the leaders were not heeding the fact that conditions in the United States were different from Germany, where the scientific chemists can succeed in the industries by scientific research alone. The laboratories of our universities were run on German lines but we had not the German chemical industries.

In the United States we had different chemical industries and needed different chemists to run our works.

The chemists who were turned out by our schools were known to be not well prepared for practical work. The industrial chemists of that time and of to-day (and I am one of them) had learned their profession after leaving the universities, at an unreasonable expense of time, and they had learned to realize that industrial chemistry in the United States required training which was entirely different from that required for scientific research. This being the case, it was often found a hardship, that expert testimony of scientific men not trained in industrial work would rule in the Courts against manufacturers. It was recognized to be an unfortunate conception of facts if it was taken for granted that a man who was a chemist, even in the best sense of the word, must also embrace the entire field of chemical knowledge. This seemed to be a serious mistake and recently several object lessons have been given. No doubt, men serving on many boards were splendid scientists but they necessarily had to fail, when they attempted to do expert work beyond their spheres. The most humble chemical manufacturer will be a truer expert if the question to be decided comes within the narrow sphere of his experience.

Similar considerations led the forty charter members of our Institute to form a society of manufacturers, in which every member must have expert knowledge of at least one branch of applied chemistry. Industrial chemistry is highly specialized, each specialty requiring a full man, and the A.I.C.E. hopes to have men of all specialties among its members at no distant time.

The growth of the Institute has been steady, the membership at present being about one hundred and sixty, which is about one-third of all the chemists in the U. S. who, it is thought, will be able to qualify under our constitution.

Our activities have been in many directions. Without wanting to be antagonistic to our sister societies, of whom most of us have

continued to be loyal members, we have put in earnest work to reorganize the courses for industrial chemists at our universities, and with the aid of able speakers, we have inaugurated at this meeting a debate on the reorganization of the Patent Office. We are observing the progress of the conservation movement, and shall be ready to enter into its discussion as soon as the movement has passed the sentimental stage and when it is ready for the work of engineers.

Other questions will be taken up as they offer themselves in conformity with one of the objects of this organization, expressed in our constitution, namely, to give the profession of chemical engineers such standing before the community as will justify its recognition by municipal, State and national authorities in public works.

Addresses were also made by Patent Commissioner E. B. Moore, Dr. Harvey W. Wiley and Admiral N. C. Twining.

A diamond studded gold watch fob was presented to the Secretary in recognition of his faithful and efficient service.

CONSTITUTION

ARTICLE I.

NAME.

This organization shall be termed,

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

ARTICLE II.

OBJECTS.

The objects of this organization shall be:

To advance the cause of applied chemical science.

To give the profession of Chemical Engineers such standing before the community as will justify its recognition by Municipal, State, and National authorities in public works.

To raise the professional standard among Chemical Engineers, discouraging and prohibiting unprofessional conduct.

To coöperate with educational institutions for the improvement of the education of the men who are to enter this profession.

To encourage original work in chemical technology.

To promote pleasant acquaintance and social and professional intercourse among its members.

To publish and distribute such papers as shall add to classified knowledge in chemical engineering and shall increase industrial activity.

ARTICLE III

MEMBERSHIP

SECTION 1. (*Qualifications for Membership.*) Membership shall consist of two grades: Active and Junior.

ACTIVE MEMBERSHIP shall require the following preparation and training:

All candidates must be not less than 30 years of age and must be proficient in chemistry and in some branch of engineering as applied to chemical problems, and must at the time of election be engaged actively in work involving the application of chemical principles to the arts. All candidates for admission to this Institute are expected to have *expert knowledge of at least one branch of applied chemistry.* and must fulfill one of the following requirements:

1. Candidates who hold no degree from an approved university or technical school must have had ten years' experience in chemical technology; five being in responsible charge of operations requiring the elaboration of raw materials, the design of machinery involving chemical processes, or the application of chemistry to industry.

2. Candidates who hold the degree of A. B. (Bachelor of Arts) from an approved university or technical school offering a four-year course must have had at least eight years of practical experience as outlined under No. 1.

3. Candidates who hold the degree of Ch. E. (Chemical Engineer), B. S. (Bachelor of Science), in Chemistry or Chemical Engineering, or E. E. (Electrical Engineer), C. E. (Civil Engineer), or M. E. (Mechanical Engineer), or equivalent degrees from an approved university or technical school offering at least a four-year course, must have had at least five years' practical experience as outlined under No. 1.

4. For candidates who in addition hold the degree of Ph. D. (Doctor of Philosophy) or Sc. D. (Doctor of Science) in Chemistry, the number of years required to earn the higher degree may be deducted from the number of years of experience required.

Junior Membership shall require the following preparation and training:

All candidates must be not less than 23 years of age and must be engaged, at the time of election, in some branch of applied chemistry and must fulfill one of the following requirements:

1. Hold the degree of Ch.E. (Chemical Engineer), B.S. (Bachelor of Science) in Chemistry or Chemical Engineering, E.E. (Electrical Engineer), C.E. (Civil Engineer), M.E. (Mechanical Engineer), or equivalent degree from an approved university or technical school offering at least a four years' course.

2. Have had five years' experience in Applied Chemistry.

Junior Members shall have all privileges of the Institute excepting those of voting, holding office, and wearing the emblem or badge of Active Membership. A suitable emblem or badge of Junior Membership as adopted by the Institute may be worn by the Junior Members. When qualified, a Junior Member may apply for Active Membership, but must do so before reaching the age of 35, otherwise his membership shall expire.

Section 2. (*Applications.*) All applications for membership must be made to the Secretary in writing, and shall embody a concise

statement with the dates of the candidate's professional training and experience, and shall be in a form and in such detail as may be prescribed by the Membership Committee. The applicant for Active Membership shall give the names of at least five members to whom he is personally known. The applicant for Junior Membership shall give the names of at least five persons to whom he is personally known, two of whom shall preferably be members of the Institute. Each of these shall be requested by the Secretary to certify to the training, experience, professional attainment, and standing of the applicant. On receiving a favorable report from at least three of these references, the applicant shall be eligible to recommendation by the Membership Committee.

Section 3. (*Election of Members.*) At stated periods the Secretary shall mail to the members a ballot containing a list of all applicants who have been recommended by the Membership Committee. This list shall contain a detailed statement of each applicant's career and the names of the members who have vouched for him. All ballots shall be returned to the Secretary not later than three weeks after the date of issue. The ballots shall be canvassed by the Membership Committee, who shall report to the Council, who shall then declare each applicant elected for whom at least ninety-five per cent. of all ballots cast are in the affirmative. Provided, however, that any member voting in the negative may address a confidential letter to the Council, stating his objections to the candidate with evidence for the charges made. If the Council upon investigation considers such objections valid, they may declare an election void. A rejected candidate may make application again any time after one year. Persons elected to membership shall be notified at once by the Secretary. They must then subscribe to the rules of the Institute.

Section 4. (*Honorary Members.*) As the result of unusual ability and public recognition on the part of the industrial world, a person may, upon nomination of the Council and a vote of the Society at large, be made an Honorary Member, but at no time shall this number exceed five.

Section 5. (*Expulsions.*) For abuse or misuse of the privileges of the Institute or conduct unbecoming a member in the opinion of the Council, a two-thirds vote of the Council may expel any member of the Institute.

Section 6. (*Dues.*) The entrance fee for Active Members shall be $15.00; Junior Members shall pay no entrance fee; Annual dues

for active members $15.00, for Junior Members $10.00. Junior Members, on becoming Active Members, shall pay an entrance fee of $15.00 less $1.00 per year for each year of their membership as Junior Members. Provided, however, that no entrance fee shall be exacted until the membership shall reach 200.

Any member may anticipate his dues for life by paying in advance such a sum as would be demanded by any reputable insurance association to yield an annuity equal to the annual dues from the time of the agreement until death. Upon resignation, or expulsion, all money so provided is to become the property of the Institute. Any person joining the Institute after the middle of the fiscal year is required to pay one-half of the dues only for that year. Any person in arrears for three months shall be notified by the Secretary. For nonpayment at the expiration of one-half year, a member forfeits the right to vote or to receive the notices of the Association until dues are paid in full. All members are considered as such unless actual resignations are formally presented and accepted with the full payment of dues. On account of extenuating circumstances, dues may be remitted to any member by a two-thirds vote of the Council.

ARTICLE IV.

OFFICERS.

Section 1. The officers of this Society shall be a President, three Vice-Presidents, a Secretary, a Treasurer, an Auditor, and nine Directors. The officers shall be elected at the annual meeting. The President shall serve one year, the Vice-Presidents for three years each, and the Directors for three years each. The Secretary, Treasurer, and Auditor shall be elected for terms of one year each. At the first annual meeting one Vice-President shall be chosen for one year, one for two years, and one for three years. Three Directors shall be chosen for one year, three for two years, and three for three years. Thereafter, officers shall be chosen annually to serve full terms. The President, Ex-Presidents for the two years succeeding the expiration of their term of office as President, Vice-Presidents, Secretary, Treasurer, and Directors shall constitute the Council of the Institute. The President, Vice-Presidents, and Directors cannot be re-elected within the current twelve months from the expiration of term. The duties of office begin immediately after election and notification. An acceptance of office must be in writing addressed to the Secretary. Vacancies occurring in any office shall be filled by a majority vote of the Council for the

unexpired term. The duties of all officers shall be such as usually pertain to their offices or may be delegated to them by the Council or the Institute.

Section 2. (*Election of Officers.*) After the election at which this Constitution is adopted, the election of officers shall be by letter ballot. The Secretary, at least eight (8) weeks prior to each annual meeting, shall send to every member of the Institute a blank nominating ballot upon which the member may make nominations for the officers and Directors to be elected at the coming annual meeting. The nominating ballot is then to be properly signed and transmitted to the Secretary not later than five (5) weeks prior to the annual meeting. It shall then become the duty of the Secretary to prepare and issue an official ballot upon which shall appear the names of all nominations for office or for Directors which shall have appeared upon at least ten (10) nominating ballots. The official ballots shall be mailed not later than three (3) weeks prior to the annual meeting, one to each member, who shall properly signify on it his choice for the various offices and Directors, and transmit it to the Secretary. At the annual meeting the President shall appoint tellers to whom the Secretary shall deliver all the ballots received by him unopened, and who shall count and announce the vote.

ARTICLE V

COUNCIL

The Council shall have supervision and care of all property of the organization, and shall conduct its affairs according to the Constitution and By-Laws. At each annual meeting it shall present a statement of its proceedings during the year. Eight members of the Council called together by notice from the Secretary shall constitute a quorum, provided, however, that three members may be represented by proxy.

ARTICLE VI.

STANDING COMMITTEES.

The Council shall appoint the following committees:

1. FINANCE.
2. COMMITTEE ON MEETINGS.
3. PUBLICATIONS.
4. MEMBERSHIP.
5. LIBRARY.
6. HOUSE COMMITTEE.

FINANCE COMMITTEE.

The Finance Committee shall have charge of the financial affairs of the Institute. This committee must prepare the budget and approve all expenditures. The Chairman of the Committee may be the Auditor of the Institute.

MEMBERSHIP COMMITTEE.

The Membership Committee shall be constituted of fifteen members, ten of whom may vote by proxy at any meeting. To the Membership Committee all applications for membership shall be referred. It is the duty of this committee to see that no person is admitted to the organization who is not qualified.

COMMITTEE ON MEETINGS.

This committee shall have charge of all meetings of the organization and shall fix dates and places of meeting.

COMMITTEE ON PUBLICATIONS.

This committee shall look after the papers presented to the Institute. If considered expedient, any or all of these papers may be published and distributed to members.

LIBRARY COMMITTEE.

This committee shall have charge of all permanent records, books, papers, pamphlets, etc., and shall obtain and place on file a complete record of all patent literature in reference to chemical engineering.

HOUSE COMMITTEE.

This committee shall look after the social affairs of the Institute fixing the time and place of entertainments.

ARTICLE VII.

MEETINGS.

The annual meeting of the Association shall be held in December, the exact date to be fixed by the Council.

This Institute shall be governed by its Constitution in conformity with the laws of the United States. All questions shall be decided by majority of votes cast. The Institute shall not be held responsible for opinions expressed in papers. The name or use of the Institute shall not be tolerated for any commercial purpose.

Upon the adoption of this Constitution officers shall be elected immediately to hold office until the election and installation of their successors.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

Any member may propose an amendment by addressing the Secretary. At the first regular meeting thereafter the subject shall be discussed, and if worthy, notice to vote on same shall be posted until the next regular meeting, and written copy of the notice shall be sent to each member. The proposed amendment shall then be discussed in open meeting and can be passed by two-thirds vote of all members of the Institute as the result of letter ballot.

BY-LAWS

ORDER OF BUSINESS.

REGULAR MEETING.

Reading of minutes of last stated meeting.
Miscellaneous announcements.
Reading of papers, discussion, and communications.
Adjournment.

ANNUAL MEETING.

Reading of minutes of last stated meeting.
Miscellaneous announcements.
Stated business.
Annual reports.
Election of officers.
Address of retiring President, etc.
Adjournment.

In all questions requiring parliamentary ruling not provided for by the Rules of the Institute, "Robert's Rules of Order" shall be the governing authority.

OFFICERS AND COMMITTEES FOR 1912

COUNCIL

Elected at the Washington Meeting, December 20, 1911

President,
L. H. Baekeland . . . . . Yonkers, N. Y.
Vice-Presidents,
Eugene Haanel . . . . . Ottawa, Ont.
T. B. Wagner . . . . . New York, N. Y.
M. C. Whitaker . . . . . New York, N. Y.
Secretary,
John C. Olsen . . . . . Polytechnic Inst., Brooklyn, N. Y.
Treasurer,
F. W. Frerichs . . . . . 4320 Washington Bou., St. Louis, Mo.
Auditor,
G. W. Thompson . . . . . Brooklyn, N. Y.
Ex-Presidents,
Chas. F. McKenna . . . . New York, N. Y.
F. W. Frerichs . . . . . St. Louis, Mo.

Directors for One Year

John T. Baker . . . . . Phillipsburg, N. J.
Wm. M. Grosvenor . . . . . New York, N. Y.
Richard K. Meade . . . . . Baltimore, Md.

Directors for Two Years

Edw. G. Acheson . . . . . Niagara Falls, N. Y.
Wm. M. Booth . . . . . Syracuse, N. Y.
Edw. Hart . . . . . Easton, Pa.

Directors for Three Years

A. C. Langmuir . . . . . Brooklyn, N. Y.
H. S. Miner . . . . . Gloucester City, N. J.
A. Bement . . . . . Chicago, Ill.

COMMITTEE ON PUBLICATIONS

Frerichs, F. W., Chairman
Andrews, Launcelot W.
Hart, Edward
Bain, J. Watson
Kippenberg, Henry
Olsen, J. C.
Ittner, M. H.

MEMBERSHIP COMMITTEE

Langmuir, A. C., Chairman
Adamson, Geo. P.
Bassett, Wm. H.
Bement, A.
DeCew, J. A.
Dow, A. W.
Ittner, M. H.
Rosengarten, Geo. D.
Kaufmann, H. M.
Miner, H. S.
Olney, L. A.
Richards, J. W.
Robertson, A.
Thompson, G. W.
Wagner, T. B.

CHAIRMEN OF LOCAL COMMITTEES ON MEMBERSHIP

Belden, A. W.	Pittsburg, Pa.
Lihme, I. P.	Cleveland, Ohio
Rosengarten, Geo. D.	Philadelphia, Pa.
Byers, H. G.	Seattle, Wash.
Wagner, T. B.	New York, N. Y.
Little, A. D.	Boston, Mass.

COMMITTEE ON CHEMICAL ENGINEERING EDUCATION

Sadtler, Samuel P., Chairman
Booth, Wm. M.
Withrow, Jas. R.
Whitaker, M. C.
Wiechmann, F. G.

COMMITTEE ON MEETINGS

McKenna, Chas. F., Chairman
Andrews, Launcelot W.
Booth, Wm. M.
Minor, John C., Jr.
Langmuir, A. C.
Meade, R. K.
Olsen, J. C.
Sadtler, S. S.

FINANCE COMMITTEE

Thompson, G. W., Chairman
Dannenbaum, H.
Adamson Geo. P.

COMMITTEE ON MEDAL

Booth, Wm. M., Chairman
Richards, J. W.
Robertson, A.
Sadtler, Samuel P.

COMMITTEE ON STANDARDIZATION OF BOILER TESTS

BEMENT, A.
BOOTH, WM. M.
CAMPBELL, J. H.
PRENTISS, GEO. N.

LIBRARY COMMITTEE

ALEXANDER, JEROME, Chairman
OLSEN, J. C.
MYERS, RALPH E.

COMMITTEE ON PATENTS

GROSVENOR, WM. M., Chairman
TOCH, MAXMILIAN
WHITAKER, M. C.

COMMITTEE ON PROFESSIONAL ETHICS

THOMPSON, G. W., Chairman
MCKENNA, CHAS. F.
LANGMUIR, A. C.
LITTLE, A. D.

COMMITTEE ON PUBLIC POLICY

TAYLOR, EDW. R., Chairman

LIST OF MEMBERS, MARCH, 1912

Honorary Member

CHANDLER, CHAS. F., Columbia University, New York City.

Active Members

AGHESON, EDWARD G., Niagara Falls, N. Y.
President, International Acheson Graphite Co.

ADAMSON, GEORGE P., 233 Reeder St., Easton, Pa.
Vice-President and General Manager, The Baker and Adamson Chemical Co.

ADGATE, MATTHEW, Naugatuck, Conn.
Supt. of the Naugatuck Chemical Co.

ALEXANDER, D. B. W., 1000 Date St., Los Angeles, Cal.
Pacific Coast Chemist for The Barber Asphalt Paving Co.

ALEXANDER, JEROME, 502 West 45th St., New York City.
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ALLEN, LUCIUS E., Box. 22, Belleville, Ont., Can.
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Research Chemist and Chemical Engineer.

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President, J. T. Baker Chemical Co.

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Metallurgist, American Brass Co.

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BEERS, FRANK T., Washburn, Wis.
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BEHREND, OTTO F., Erie, Pa.
Vice-President and Treasurer, Hammermill Paper Co.

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General Manager Central Dyestuff Chemical Co., Newark, N. J.

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SADTLER, SAMUEL S., 39 South 10th St., Philadelphia, Pa.
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Diack & Smith, Consulting Chemists.

STILLMAN, JOHN MAXSON, Stanford Univ., Cal. Professor of Chemistry.

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TAYLOR, EDWARD R., Penn Yan, N. Y. Manufacturing Chemist.

TAYLOR, JOHN, care Continental Portland Cement Co., Syndicate Trust Bldg., 10th & Olive Sts., St. Louis, Mo.

TEAS, WILLIAM H., Ridgway, Pa.
General Supt., U. S. Leather and Allied Companies.

THOMPSON, GUSTAVE W., 60 So. Portland Ave., Brooklyn, N. Y.
Chief Chemist, National Lead Co.

THORP, FRANK H., Boston, Mass.
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TRAUTWEIN, A. P., Carbondale, Pa. Pres. Carbondale Instrument Co.

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Consulting Chemist.

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JUNIORS

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ADDRESSES AND PAPERS

READ BEFORE THE INSTITUTE

SOME PROBLEMS IN CHEMICAL ENGINEERING PRACTICE

By President F. W. FRERICHS

Read at the Chicago Meeting, June 21, 1911

THE address, which I have prepared, comprises the development of three problems which actually have come under my observation. They were selected with a view of demonstrating the variety of questions, the solution of which may be expected from chemical engineers, the detail work which is necessary, and the care and training which are required for their successful solution.

The first problem solves the extraction of bismuth from ores. In this problem, the principal work is research, to develop the process which could be applied to the economical treatment of large quantities of ore. After the process was developed the translation into practice was comparatively simple and safe to predict.

The second problem treats of the transplanting of a process from Europe to the United States and will prove that a process which is profitable in one location may be a failure under different conditions.

In the third problem the details of the process were known, and it was only required to construct complicated apparatus to carry put the process on a given scale.

In my opinion, problems similar to those represented could be used successfully for object studies in the post-graduate work of chemical engineers, but it is necessary that the work be conducted by teachers, who themselves are masters of the subjects to such an extent that they would be willing to invest money of their own in the installment of plants, for which the research might be the foundation.

EXTRACTION OF BISMUTH FROM CARBONACEOUS ORES

Bismuth is not of very rare occurrence and it can be produced greatly in excess of the consumption, which, in 1910, was about 200,000 lbs. for the United States. The metal is used almost exclusively for medicinal preparations and its consumption does not materially vary with its price.

About ten years ago, being then a manufacturer of medicinal preparations, I looked for an independent supply of bismuth and turned my attention to Colorado, where I understood bismuth ores had been found. Personally going to Colorado, I examined the field but found everybody very reluctant to give information about bismuth ores. It was known that several lots had been mined in recent years, but there was no market for it in the U. S., the smelters accepting it only for gold and silver values, charging a penalty for bismuth, since it deteriorated the lead, which was added in smelting the ores.

By the efforts of an assayer in Leadville, these lots of ores had been sold to a firm in England, where they were shipped by way of Galveston. It seemed to be a condition of the sale that it should be kept a secret, and that the sellers were not to sell subsequent lots to anybody else but the purchasers of the ore. If they should sell to any other party, contrary to the understanding, the buyers threatened not to buy any more ore from them.

This being the case, I could not secure any large lot of ore, but obtained a sample of several hundred pounds to make experiments.

The sample was a siliceous ore, had the appearance of yellow clay and was typical of ores carrying about one oz. of gold, 15 ozs. of silver, 5 per cent bismuth, and 5 per cent lead in the dry ore. A sample of the dry ore, finely powdered and treated with dilute muriatic acid, gave up all of its bismuth, except about 2 per cent, and these 2 per cent could not be extracted by concentrated muriatic acid. The mixture of ore with dilute muriatic acid was exceedingly slimy and did not readily filter nor did it settle.

Another sample of the ore was ignited in the open air for several hours, was finely powdered and would then give up all of its bismuth to dilute muriatic acid. The mixture was not slimy and filtered and settled fairly well. The amount of bismuth extracted in this manner

from samples weighing from 100 to 1000 grams corresponded well with the quantity of bismuth found by analysis in the original ore.

Analyses and extractions were repeated many times with ores from as many localities as I could get hold of, until I had full confidence in my analyses.

Being thus convinced that all the bismuth indicated by analyses of the ore could be extracted, and knowing that I could sell the gold and silver values in the tailings to one of the smelters, I believed myself to be ready to purchase a larger lot of ore, if the opportunity should offer.

This opportunity presented itself sooner than I expected. A mine in which previously no bismuth ore had been found was nearing in its development an adjoining property in which bismuth ore had occurred and this mine had struck bismuth ore. The adjoining mine had produced several lots, running from 5 per cent to 15 per cent bismuth, 1 to 2 ozs. of gold, and 5 to 10 ozs. of silver. It seemed probable, but not certain, that a similar grade of ore could be taken from the new mine, and borings indicated large bodies of the material.

This mine offered to sell the entire output for a period of four years to my company. The mining company would not sell smaller lots from time to time, for fear that the English buyers would boycott them, in which case they would not have an outlet for their ore.

Desirous of obtaining possession of the ore, I negotiated a contract, by which my company agreed to take the entire output of the mine for a period of four years, which was estimated to be, and limited to the equivalent of 1600 tons of 5 per cent ore, containing 160,000 lbs. of bismuth. The ore was to be paid for at its gold and silver values, as ascertained by fire assay and for bismuth as found by wet analysis.

The sampling of the ore was to be done by public sampler, buyer as well as seller supervising the work. The final sample reduced to a 100-mesh powder was to be divided into three parts, one to go to the buyer, one to the seller, and the third sample was to be held for the umpire, in case of disagreement of analyses made by buyer and seller.

The money value of the contract can be figured if I state that the ore delivered under this contract contained at an average 1 oz. gold and 100 ozs. silver, which would make the value of the ore $180 per ton, figuring the 5 per cent bismuth at $1 per pound, which is equivalent to a total of $288,000 for the entire contract.

This very large sum of money had to be paid out on values ascertained by analyses, and the confidence which I had in the correctness of my analyses and extraction tests may be measured by the fact that an error of $\frac{1}{10}$ of 1 per cent in the analyses or extraction test for bismuth would amount to $3200 for the entire contract.

In making the agreement I had to consider that settlements would be made on the basis of analyses made by buyer and seller, and that an average of the two as a rule would be higher than the actual amount of bismuth contained in the ore.

I furthermore had to consider that there were few analytical chemists in Colorado who ever had made a bismuth analysis, and an error of 1 per cent or even more was of common occurrence. It was necessary that I be so sure of my methods of analyses and the results thereof that I could convince every analytical chemist of an error even if he was unwilling to admit it. In many instances I went to Colorado to straighten out differences, and always have succeeded in supporting my analyses. In one instance I spent about ten days in Denver, during which time I compared, together with Dr. Albert H. Low, the basic chloride method with the electrolytical determination of bismuth, proving that under proper precautions both give the same results.

As far as I know, the results of this investigation have never been published. Therefore, I will give a short account of it, giving Dr. Albert H. Low full credit for the part he took in the investigation. Our method of the determination of bismuth in ores is as follows:

Take 0.5 gram ore of No. 100 powder, treat in a 250 cc. flask with 10 cc. strong nitric acid, and boil repeatedly until the acid is nearly gone. Add 10 cc. strong muriatic acid and heat gently until decomposition is as complete as possible. Dilute with 10 cc. hot water and filter, receiving the filtrate in a 400 cc. beaker. Filter and wash residue thoroughly with warm dilute 1 to 3 muriatic acid.

Nearly neutralize the filtrate with aqua ammonia 10 per cent, dilute to about 300 cc. and precipitate bismuth, lead and other heavy metals with sulphuretted hydrogen. Filter and wash with hot water. Place the filter and precipitate in a beaker and boil with 10 to 15 cc. dilute 1 to 1 nitric acid until the separated sulphur is clean and of white color and until the filter has been reduced to a pulp (which can be hastened by stirring with a glass rod). Dilute a little and filter into a 250 cc. flask, wash thoroughly with dilute 1 to 1 nitric acid, using as little as possible so as to keep the filtrate of small bulk.

From this point on the analysis may be finished either by electrolysis or by the basic chloride method which are conducted as follows:

First. By Electrolysis. Concentrate the liquid in the flask to small bulk, best by manipulating the flask in a holder over the *naked* flame, and add 6 cc. of strong sulphuric acid. Continue boiling until the sulphuric acid is fuming strongly. Cool and add 50 cc. water. Allow to cool, filter off the sulphate of lead, and wash with a cold mixture of 6 cc. strong sulphuric acid and 75 cc. distilled water. Receive the filtrate in the beaker to be used for electrolysis and dilute to 200 cc. Electrolyze with a current of 0.5 to 0.6 ampere and increase the current to 1 ampere towards the end of the operation. As cathode use a platinum cylinder 5 cm. long and 2.5 cm. in diameter. As anode use a platinum spiral made from 1 mm. wire.

For the electrolytic method the final solution should not contain more than 0.03 gram bismuth. If larger samples are taken bismuth is liable to drop off from the cathode and is difficult to collect. It is necessary to weigh in every instance the anode also, since small quantities of bismuth peroxide deposit there in protracted analyses, the amount of which must be added to the bismuth deposited on the cathode. The weights should be ascertained on a gold balance, weighing up to $^1/_{100}$ of 1 mg., and in careful work two analyses made from the same pulp should agree to within $^1/_{100}$ of 1 per cent for bismuth.

Second. The Basic Chloride Method. Receive the filtrate in a 400 cc. beaker and dilute with hot water to about 250 cc. Heat nearly to boiling and neutralize cautiously with 10 per cent ammonia, until an exceedingly faint opalescence is observed in the liquid. Dilute to about 350 cc. with hot water, add 1 cc. dilute 1 to 3 muriatic acid and 2 to 3 cc. of a saturated solution of ammonium chloride, cover the beaker and keep it *nearly* at boiling-point until the basic chloride of the bismuth has settled clear or nearly so, filter and wash with hot water. The basic chloride of bismuth obtained in this first precipitation may be contaminated with a little lead and for this reason it is dissolved on the filter in hot dilute 1–1 nitric acid, and the basic chloride of bismuth precipitated from the filtrate in the same manner as before. Finally, collect the basic chloride of bismuth on a weighed filter, dry at 110° C. in the air bath and weigh.

Note 1. If the ore contains arsenic or antimony, the precipitate made by treatment with sulphuretted hydrogen should be washed,

first, with water and then two or three times with a warm solution of ammonium sulphide and then again with hot water before proceeding.

Note 2. In case the ore contains silver, this should be removed by adding a single drop of strong muriatic acid to the original dilute nitric acid solution before filtering. The coagulation of the silver chloride should be facilitated by shaking, but care should be taken not to dissolve it again by heating.

Note 3. For quick working it is essential that no larger quantities of reagents and no larger vessels are used than indicated in the directions. If the directions are closely followed the determination of bismuth in ore can be carried out in four hours by either method.

Having received deliveries under the contract and having also secured several lots of ore and ore samples from other mines, laboratory tests of a great variety were carried out with these ores with a view of designing a process of extraction, which would fit as great a variety of ore as possible. The results of these laboratory tests could be tabulated as follows:

1. All bismuth ores to be considered were of siliceous character. The gangue had an average of

50—60	per cent silica,
22—18	per cent iron oxide,
19—15	per cent alumina,
9— 7	per cent barium sulphate,
100 100	

and the ore contained 2 to 15 per cent bismuth, 1 to 10 per cent of lead by wet analyses, from 0 to 5 ozs. gold, and from 1 to 150 ozs. of silver by fire assay.

2. All ores had the appearance of yellow clay. If ground up in water they were very slimy, would not settle or filter, and the values could not be concentrated in the ore by the ordinary methods of concentration. The following experiments were carried out in a well equipped sampling and testing works with good machinery, and proved in all cases that too much bismuth remained in the tailings, and that only from $\frac{1}{2}$ to $\frac{2}{3}$ of the bismuth contained in the ore could be worked into a more concentrated form. In one instance in which a coarser ore had been used for the test from which the slime

had been eliminated, the concentration of the bismuth was greater, but in no case could a sufficiently concentrated ore be obtained from which the bismuth could be separated in a satisfactory manner by smelting.

Exp. 1.—100 lbs. ore containing 11.80 per cent bismuth produced 13.2 lbs. concentrates containing 63.70 per cent = 8.4 lbs. bismuth. 86.8 lbs. tailings containing 3.90 per cent = 3.4 lbs. bismuth.

Exp. 2. 100 lbs. ore, containing 9.00 per cent bismuth, produced 18.2 lbs. concentrates containing 31.20 per cent = 5.68 lbs. bismuth. 81.8 lbs. tailings containing 4.05 per cent = 3.32 lbs. bismuth.

Exp. 3. 100 lbs. ore, containing 15.30 per cent bismuth, produced 47.2 lbs. concentrates, containing 30.40 per cent = 14.35 lbs. bismuth. 52.8 lbs. tailings containing 1.80 per cent = 0.95 lbs. bismuth.

3. Raw ores would give up only 85 to 95 per cent of the bismuth contained therein to dilute hydrochloric acid, or to a dilute solution of sulphuric acid and sodium chloride. The bismuth so extracted was free from arsenic.

Example. 100 grams raw ore, No. 100 powder, containing 11.51 per cent bismuth by analysis extracted by 500 cc. of dilute (10 per cent) muriatic acid, produced only 9.88 grams bismuth out of a possible 11.51 grams. The solution was only 19 per cent saturated and could extract more than five times as much bismuth oxide. The extracted ore was filtered off and washed on the filter with 4 per cent muriatic acid until the filtrate did not contain any more bismuth. The ore thus extracted, mixed with 500 cc. of 10 per cent muriatic acid and shaken in a machine for twenty hours, would not give up any more bismuth to the solution. 1.62 per cent bismuth remained in the ore and could not be dissolved by dilute (10 per cent)muriatic acid.

The same experiment was repeated with 100 grams of the same ore and a mixture of 500 cc. dilute (13.43 per cent) sulphuric acid (which is equivalent to 10 per cent muriatic acid) and 80 grams sodium chloride (the mixture measuring 531 cc.). All other conditions were the same as in the foregoing experiment. 9.667 grams of bismuth out of a possible 11.51 grams could be extracted, and this bismuth was free from arsenic while the ore contained this element in considerable quantity. The balance of 1.84 per cent bismuth could not be extracted by dilute acid solution, but its presence in the tailings could be proven by analysis.

4. Raw ores mixed with sodium chloride and subsequently roasted lose part of their bismuth by volatilization.

Experiment. 300 grams raw ore, containing 1.84 per cent bismuth mixed with 30 grams sodium chloride and roasted in a muffle furnace for six hours to dark red heat, contained after roasting only 0.3 per cent bismuth by electrolysis.

5. Raw ores, reduced to a No. 30 mesh powder and subjected to an oxidizing roasting for several hours, settle and filter fairly well, and in this form the ore is fit for extraction.

6. Roasted ores, especially if they are moistened with small quantities of sulphuric acid before roasting and reduced to a No. 30 powder, will give up all of their bismuth to an *excess* of cold dilute muriatic acid or to an equivalent solution of sulphuric acid and sodium chloride, but the bismuth so extracted contains arsenic.

Experiment 1. Three samples of 100 grams each of roasted ore, No. 30 powder, containing 11.51 per cent bismuth, were extracted each with 250 cc., 13.43 per cent sulphuric acid, and 40 grams sodium chloride. The samples were shaken in a machine for one, two and twelve hours, respectively, at 15° C. In each case 100 cc. of the filtrate were precipitated with 1500 cc. of water and the basic chloride of bismuth was filtered off, dried and reduced to metal by melting with cyanide of potassium and from the weight of the bismuth, the amount contained in the entire solution was calculated.

Sample No. 1, shaken 1 hour, produced 11.25 grams bismuth.

Sample No. 2, shaken 2 hours, produced 11.11 grams bismuth.

Sample No. 3, shaken 12 hours, produced 11.44 grams bismuth, which proved practically complete extraction of bismuth from the roasted ore. The acid in these cases was very much in excess of the bismuth oxide contained in the ore for which reason the solutions were very acid, requiring much water for precipitation; besides there was a great waste of acid. With less acid, extraction would not be complete.

Experiment 2. 2000 grams of dry, raw bismuth ore, No. 100 powder, containing 11.51 per cent bismuth by analysis, mixed with a solution containing 4000 cc. 13.43 per cent sulphuric acid, and 640 grams sodium chloride were shaken in the machine for fourteen hours, and gave, upon filtration, which was not followed by washing, 3186 cc. filtrate, equal to 7.6 per cent muriatic acid by titration. This solution, upon precipitation with much water, separated suf-

ficient basic chloride of bismuth to make 139.0 grams bismuth metal by melting with potassium cyanide.

The material, which remained on the filter, was washed with 1000 cc. $7\frac{1}{2}$ per cent, muriatic acid and drained until 1000 cc. had filtered off. From this filtrate the basic chloride of bismuth was precipitated, and made 15.6 grams bismuth by melting with potassium cyanide.

The washing of the material on the filter was followed by three subsequent washings, the first time with 2000 cc. of 5 per cent muriatic acid, the second time with 2000 cc. of 3 per cent, and the third time with 2000 cc. of 1 per cent muriatic acid. In each washing, 1750 cc. filtrate were collected from which 14.9 grams, 8.9 grams, and 4.4 grams, respectively, of bismuth metal were obtained by melting the basic chloride of bismuth with potassium cyanide.

The last washing was done with 200 cc. water and the resulting filtrate yielded 0.7 gram bismuth.

The exhausted ore weighed 1675 grams after drying. It was moistened with 65 cc. strong sulphuric acid and roasted in a muffle furnace for four hours at a dark red heat.

After roasting it was extracted again with a solution of 3000 cc. 13.43 per cent sulphuric acid, and 480 grams sodium chloride. The extraction was accomplished by shaking the mixture for 14 hours in a machine and after precipitating the solution and melting the basic chloride of bismuth with potassium cyanide, 29.5 grams bismuth were recovered.

The tailings from the second extraction proved still to contain 0.28 per cent bismuth by electrolysis.

The results of the successive extractions are given in Table I.

7. Roasted ores cannot readily be extracted by 13.43 per cent sulphuric acid, without the addition of sodium chloride.

8. Roasted ores surrender their bismuth to 10 per cent hydrochloric acid or to an equivalent solution of sulphuric acid and sodium chloride completely only upon boiling, making fairly neutral solutions.

Experiment. Roasted ore, containing 4.99 per cent of bismuth after extraction with diluted sulphuric acid and sodium chloride showed only 0.03 per cent bismuth in the tailings.

By these observations, the conclusion has been reached that the extraction of the bismuth from the ore by dilute muriatic acid would be most complete and at the same time economical. The

TABLE I

EXTRACTION OF BISMUTH FROM ORE BY SUCCESSIVE TREATMENT WITH ACID SOLUTIONS

2000 grams of raw dry bismuth ore 100 powder, containing 11.51% Bi; 4000 cc. diluted sulphuric acid, 13.43%; 600 grams sodium chloride, making 4248 cc. solution. Extracted as described above.

Number of Extraction.	Extracting Solution, cc.	Acidity, % HCl.	Filtrate, cc.	Bismuth Extracted Grams.
1st	4248	10.0	3186	139.0
2d	1000	7.5	1000	15.6
3d	2000	5.0	1750	14.9
4th	2000	3.0	1750	8.9
5th	2000	1.0	1750	4.4
6th	200	0.0	.....	0.7
Total bismuth free of arsenic, gms				183.5
1675 grams tailings roasted with 65 cc. concentrated sulphuric acid and extracted gave bismuth				29.5
Tailings from second extraction had 0.28% bismuth				4.6
Lost in roasting and otherwise				12.6
Total, grams				230.2

latter was particularly so since a dilute solution of sulphuric acid and sodium chloride in the proportion of the molecular weights could be substituted for hydrochloric acid. Cheap sulphuric acid manufactured as a by-product from the roasting process of zinc ores was at my disposal.

For this reason it was decided to work out systematically a process of extracting bismuth from the ore by dilute hydrochloric acid and also by dilute solution of sulphuric acid and sodium chloride of the same acidity.

The general idea of the work was to obtain a solution of bismuth chloride, to precipitate the bismuth in the form of basic chloride of bismuth by the addition of much water, and to recover the metals remaining in the solution by sodium sulphide in form of a black precipitate of the metallic sulphides. From the basic chloride of bismuth, the metal was to be obtained by melting with charcoal, soda, and potassium chloride; the metal sulphides after roasting were to be worked up by methods suitable to extract the various metals from them.

The chemical reactions and properties of the materials involved in these operations were first studied on pure chemicals.

1. The solubility of basic chloride of bismuth in dilute muriatic acid of various strengths.

These determinations were made by shaking in a shaking machine for 8 to 12 hours at a temperature of 15° C. a flask containing 500 cc. dilute acid solutions of various strengths with an excess of basic chloride of bismuth of high purity, free from bismuth hydroxide. In the resulting solution, after filtering, the acid as well as the basic chloride of bismuth was quantitatively determined by the following method:

10 cc. of the solution were titrated with normal solution of caustic alkali (phenolphthalein serving as the indicator). By special experiment it had been proven that all of the bismuth had been precipitated from the solution as basic chloride of bismuth a little before the moment, when the phenolphthalein turned pink, and the number of cc. of the normal solution of caustic potash indicated the amount of acid, which held the basic chloride of bismuth in solution.

In a second sample 10 cc. of the same solution, the bismuth was determined by precipitation and weighed as bismuth oxide. The values found for the solubility of basic chloride of bismuth in dilute muriatic acid of various strengths are entered in Table II.

TABLE II

SOLUBILITY OF BASIC BISMUTH CHLORIDE IN MURIATIC ACID OF VARIOUS STRENGTHS

Bi 208, Cl 35.5

Basic Chloride of Bismuth Free from Oxide, Grams.	Diluted Acid Used.		Time of Shaking, Hours.	10 cc. Filtered Solution		
	cc.	Containing HCl, %		Contain:		Are Equal to Normal Solution KOH, cc.
				Bi_2O_3, Grams.	BiOCl, Grams.	
10	500	1	36	0.0015	0.0017	2.7
20	500	2	36	0.0225	0.0252	5.5
30	500	3	36	0.112	0.125	8.3
40	500	4	36	0.251*	0.281	11.0
50	500	5	36	0.413	0.462	13.75
60	500	6	12	0.550	0.615	16.4
70	500	7	12	0.767	0.858	19.1
80	500	8	12	0.963	1.077	22.0
90	500	9	12	1.157	1.294	24.6
100	500	10	12	1.398	1.562	27.4

2. The solubility of the basic chloride in a dilute solution of sulphuric acid and sodium chloride of an acidity equivalent to 10 per cent hydrochloric acid is somewhat less than the solubility in pure dilute muriatic acid. Exact determinations were made in the same manner as described in the determination of solubilities in muriatic acid.

As an average of two determinations, it was found that 71.57 grams of basic chloride of bismuth could be dissolved in a solution made from 500 cc. sulphuric acid, 13.43 per cent, and 80 grams sodium chloride, while 78.10 grams basic chloride of bismuth could be dissolved in 500 cc. of dilute muriatic acid, 10 per cent.

3. The solubility of basic chloride of bismuth in very dilute muriatic acid was ascertained in the same manner as the solubility in dilute hydrochloric acid from 1 to 10 per cent, as described above, and the values found were entered in Table III:

TABLE III

SOLUBILITY OF BASIC CHLORIDE OF BISMUTH IN VERY DILUTE MURIATIC ACID

Bi 208, Cl 35.5

BiOCl Used, Grams.	Diluted HCl			Time of Shaking, Hours.	10 cc. Filtered Solution			
					Contain:		Are Equal to Normal Solution KOH.	
	Normal HCl, cc.	Water, cc.	Mixture Contains HCl, %.		Bi_2O_3, Grams.	BiOCl, Grams.	Found, cc.	Should be, cc.
4	40	460	0.292	8	none	none		
6	60	440	0.438	8	none	none		
8	80	420	0.584	8	none	none		
10	100	400	0.730	8	none	none	1.9	2.0
20	200	300	1.460	8	0.0067	0.0075	3.9	4.0
30	300	200	2.190	8	0.0300	0.0335	5.5	6.0
40	400	100	2.920	8	0.0863	0.0965	7.7	8.0
50	500	.....	3.650	8	0.1590	0.1778	9.7	10.0

This table is slightly incorrect, since the basic chloride of bismuth used for this determination contained a trace of bismuth oxide. For this reason the figures in the second last column are slightly smaller than they are in the last column. For practical purposes, however, the values of the table were considered sufficiently correct.

4. Precipitation of basic chloride of bismuth from its solution in dilute hydrochloric acid, and in solutions of dilute sulphuric acid and sodium chloride by dilute alkali solutions.

It was ascertained that a normal solution of caustic potash gradually added to a solution of basic chloride of bismuth in dilute hydrochloric acid, or in a dilute solution of sulphuric acid and sodium chloride, will precipitate basic chloride of bismuth, and if phenolphthalein is used as an indicator, the solution will turn pink at the moment when all of the solvent acid is neutralized.

A little prior to this point all of the basic chloride of bismuth was precipitated from the solution.

5. The properties of solutions obtained by extracting bismuth ores with dilute solutions of sulphuric acid and sodium chloride must necessarily vary since, in addition to bismuth, more or less iron is extracted from the ore. A mixture of 1100 parts by weight of sulphuric acid, 13.43 per cent (12.5° Bé.), and 160 parts sodium chloride, having a specific gravity of 23° Bé., was found most suitable for extracting the ore. This acid mixture filtered through rich bismuth ore, containing 7 to 12 per cent of the metal, increases its specific gravity to 40° Bé., however, in the same proportion as the ore becomes exhausted, the specific gravity of the filtrate decreases, and the percentage of bismuth contained therein is growing less. Table IV gives the approximate relation between the specific gravity of the filtrate and of the bismuth contained in same.

TABLE IV

RELATION OF SPECIFIC GRAVITY OF BISMUTH CHLORIDE SOLUTIONS CONTAINING SULPHATES AND BISMUTH CONTAINED IN SAME

100 cc. Contain:		100 cc. Contain:		100 cc. Contain:	
°*B′*	Bi Grams.	°*B′*	Bi Grams.	°*B′*	Bi Grams.
25	0.2	31	5.3	37	8.5
26	1.1	32	6.0	38	8.9
27	2.0	33	6.6	39	9.3
28	2.9	34	7.1	40	9.7
29	3.7	35	7.6	41	10.1
30	4.5	36	8.1	42	10.5

It is not desirable to work with solutions which are stronger than 40° Bé., since they tend to crystallize at temperatures below 15° C.

and are liable to prevent the filtering of the solutions through the ore.

In order to ascertain the degree of dilution with water necessary to precipitate the basic chloride of bismuth from this solution the following determinations were carried out:

100 cc. bismuth solution, 40° Bé., 300 cc. water, precipitate, 9.0 grams basic chloride of bismuth.

100 cc. bismuth solution, 40° Bé., 400 cc. water, precipitate, 10.1 grams basic chloride of bismuth.

100 cc. bismuth solution, 40° Bé., 500 cc. water, precipitate, 10.1 grams basic chloride of bismuth.

And in using a different solution:

100 cc. bismuth solution, 500 cc. water, precipitate 13.1 grams basic chloride of bismuth.

100 cc. bismuth solution, 1000 cc. water, precipitate, 12.9 grams basic chloride of bismuth.

100 cc. bismuth solution, 1500 cc. water, precipitate, 12.8 grams basic chloride of bismuth.

These experiments indicate that dilution of a concentrated solution with five times its volume of water will precipitate practically all of the bismuth which is in solution.

6. Recovering the metal values from the solutions resulting from the precipitation of basic chloride of bismuth.

The valuable metals which could remain in the solution could all be precipitated by sulphuretted hydrogen, and precipitation with sulphide of sodium from the acid solution proved to be the cheapest way to accomplish this end.

A solution obtained by boiling 690 lbs. of caustic soda, 74 per cent, 460 lbs. of sulphur flour and sufficient water to make 40 cu.ft. was found suitable for the purpose. The sulphides of the heavy metals settled quickly and the resulting solutions were run to waste. The metal sulphides were collected, dried, and roasted for the purpose of eliminating sulphur and the roasted product in one instance was found to contain 54.9 per cent bismuth, 4.3 ozs. silver, and 0.40 oz. of gold. This material was worked up by extraction with dilute acid in the same manner as the ore itself.

7. The reduction of basic chloride of bismuth to metal could be accomplished by melting it with a mixture of potassium chloride, sodium carbonate, and powdered charcoal, and the resulting metal

could be purified by melting with a very small quantity of caustic soda and nitrate of potassium.

After these preliminaries, the arrangement of a larger plant for the extraction of bismuth ore suggested itself. The operations which were to be executed on a larger scale were as follows:

A. To prepare the ore for extraction.

B. To extract the ore by acid solutions.

C. To recover the values from the solutions.

D. To prepare the extracted ore for shipment to smelters, where it was to be treated for its values of gold, silver, and lead.

A. Preparation of the Ore for Extraction. The raw ore as it came from the mines was in a lumpy condition and contained from 10 to 15 per cent moisture. Treated with water, it would form a slimy mixture which would not filter or settle. It could not even be filtered in filter presses or on suction filters. It would not give off all of its bismuth to dilute muriatic acid, unless it had been roasted in the open air. The ore was dry enough to run through an ore crusher in which it could be reduced to $\frac{1}{2}$ in. size. Subsequently it was dried on a drying floor, and ground in a suitable mill to No. 30 powder. Finally, the ore was roasted for 4 hours in a reverberating furnace to dark red heat, air being admitted freely to effect an oxidizing roasting process.

The roasted ore consisted of a dark red powder, all of which passed through a No. 30 sieve, and about 25 per cent of it would run through a 100-mesh bolting cloth. The mixture of the roasted ore powder and dilute muriatic acid, after boiling, would settle and filter fairly well, and in this condition the ore seemed to be well prepared for extraction with dilute hydrochloric acid or a dilute solution of sulphuric acid and sodium chloride.

The plant which was used for this operation is outlined in Fig. 1.

A line of fire-proof ore bins adjoined a switch track from which the ore was unloaded from the railroad cars. These ore bins having a granitoid floor afforded good opportunity for sampling the ore. From these bins the ore was taken to the crusher, reduced to about $\frac{1}{2}$ in. size and discharged directly on a drying floor, measuring 20 ft. × 10 ft. 6 ins. The dry ore was run through roller mills and a sifting machine, and as No. 30 powder was charged into the roasting furnace which was 40 ft. long and 12 ft. 9 ins. wide, outside measurements. The capacity of this plant was about 8 tons of dry ore per day of 24 hours, which was more than could be

worked by the lixiviation plant. But it did not seem economical

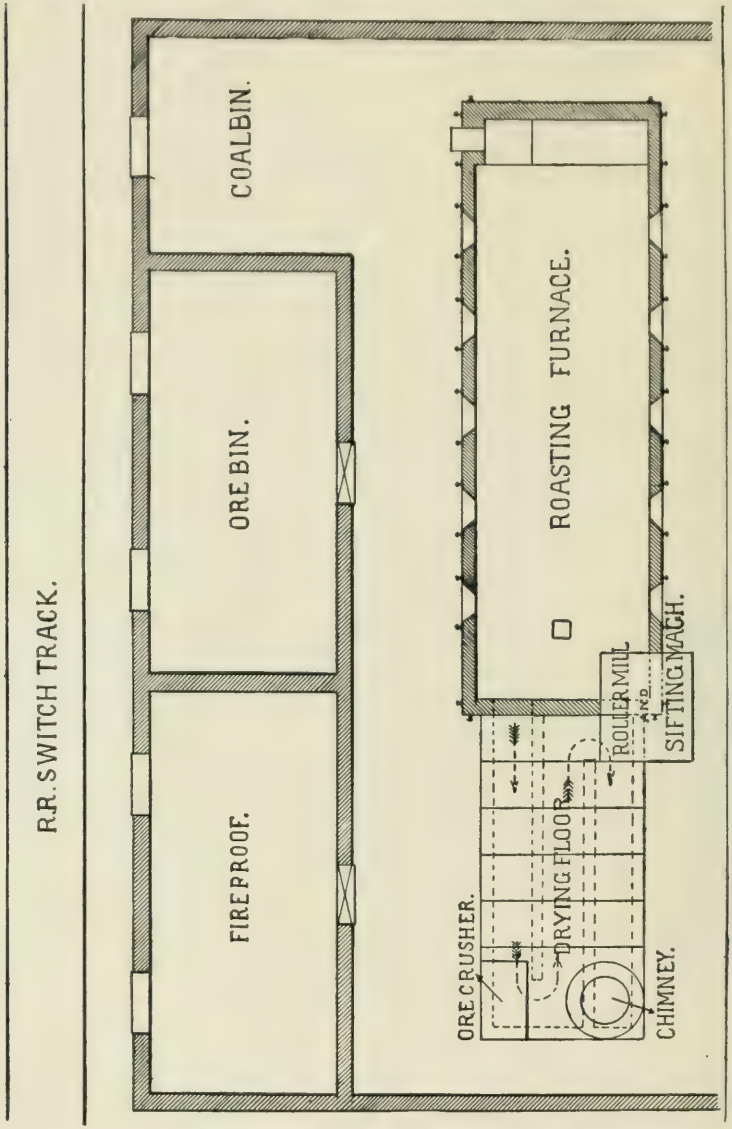


Fig. 1.—Plant for Grinding and Roasting Bismuth Ore.

to install a smaller furnace and intermittent operation was decided on.

B. Extraction of Bismuth from Roasted Ore by Acid Solutions. The ore as it came from the roaster was in the form of a No. 30 powder, about 25 per cent of which would pass a 100-mesh sieve. The

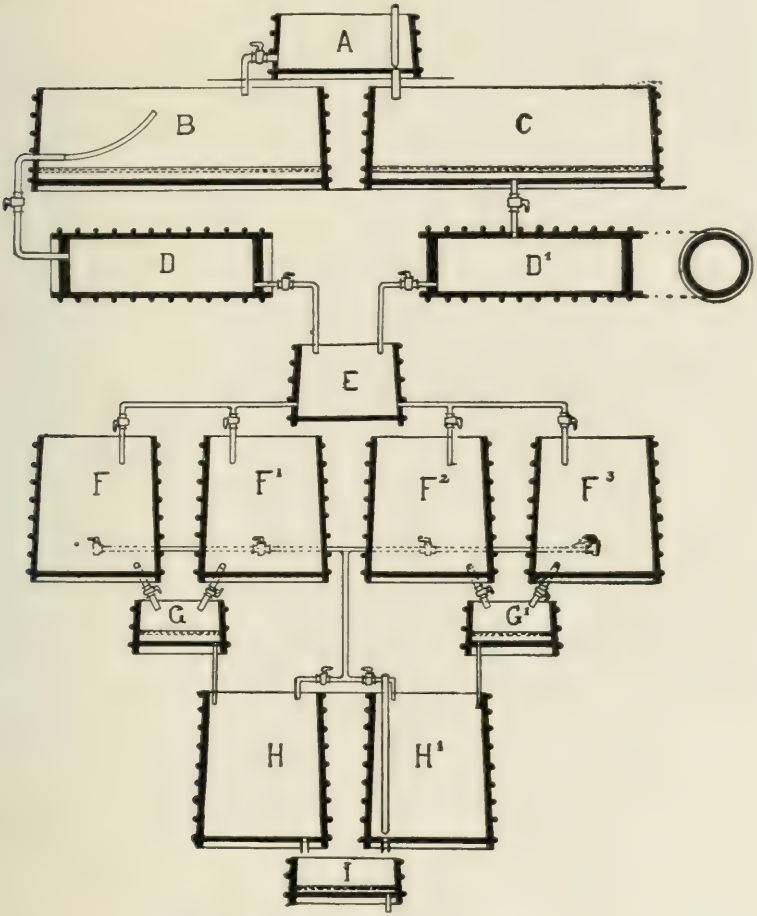


FIG. 2.—Plant for Extracting Bismuth Ore.

problem was to extract all of the bismuth with as little acid solution as possible, obtaining the most concentrated solutions, and to recover all of the metals from these solutions.

The preliminary experiments had proven that all of the bismuth could be extracted only by boiling the roasted ore with acid solutions,

and in the course of operations it was found expedient to separate immediately after boiling the fine parts from the coarser material of the ore by settling and to work each in separate operations.

An apparatus of the general arrangement outlined in Fig. 2 was thought to be suitable for this work.

The size of the various tanks was arrived at by the following considerations:

A round boiling tank, 8 ft. diameter and 3 ft. high, seemed to be the largest size in which ore could be boiled with acid solutions, allowing at the same time agitation of the ore by hand. A tank of that size would take the following charge:

3000 lbs. roasted ore, having about 5 per cent bismuth.
1200 lbs. sulphuric acid, 60° Bé.
1110 lbs. sodium chloride.
q. s. water to make 100 cu.ft. liquid.

This charge was boiled by live steam under constant stirring.

The contents of the boiling tank were separated right after boiling by running most of the solution, in which the slimes were suspended, into a vacuum filter of suitable size, whereupon the coarse settlings in the boiling tank were shoveled into another vacuum filter. 85 cu.ft. of bismuth solution could be filtered off at a vacuum of 15 ins. mercury in 12 hours.

In working this particular lot of ore, a bismuth solution of 43° Bé. could be obtained, 10 cc. of which admitted of an addition of 3 cc. normal alkali solution before a turbidity, caused by precipitation, of basic chloride of bismuth would appear.

The 85 cu.ft. bismuth solution, diluted with twice its volume of water, precipitated sufficient basic chloride of bismuth to make 141 lbs. of bismuth by melting, which indicated that $8\frac{1}{2}$ lbs. bismuth were contained in the solution which could not be separated from the ore without washing.

The slimes remaining in the filter tank after draining consisted of about 8 cu.ft. of very sticky material, containing 28 per cent moisture.

The coarser ore in the other filter tank measured about 30 cu.ft., contained 14 per cent moisture, and had in a moist state a weight of 88 lbs. to the cu.ft.

To accommodate the coarse tailings from 50 tons ore in one ore filter, a space of 1000 cu.ft. was necessary, and a round filter tank, " C," of 16 ft. diameter and 6 ft. high was erected for the work.

A settling filter, " B," of the same size as ore filter " C " was provided for the slimes, and this was arranged in such a manner that the larger part of the clear liquid could be drawn off from the top after settling, while only a small proportion needed to filter through the slimes.

Vacuum vats " D " and " D_1," 3 ft. in diameter and 12 ft. long, were connected with the filters, and a vacuum of 10 to 15 ins. of mercury was maintained in same.

C. Recovering the Values from the Solutions. It was found necessary to have four precipitating tanks, F, F_1, F_2, and F_3, each 7 ft. diam. and 8 ft. high, for the purpose of precipitating basic chloride of bismuth, and 2 precipitating tanks, H and H_1, of the same size for sulphides, in order to keep up with the work in the boiling tank.

Two filter vats, G and G_1, 5 ft. diameter and 2 ft. high, served for draining the basic chloride of bismuth, and one filter vat of the same size and marked I in the drawing, for draining the sulphides.

The capacity of the plant proved to be six tons of 5 per cent bismuth ore per day. This work could be carried on for about eight days, until the ore filter was full of coarse tailings and it required from three to six days to wash the material on the filter and get ready for a new lot.

The average capacity was about 100 tons per month, if 5 per cent ore was worked. Ores containing less bismuth could be worked more quickly, while richer ores required a longer time for boiling and lixiviation.

Metal sulphides were collected from time to time on filter I and, after drying and roasting, they were extracted in the same manner as the ore. A lot of 848 lbs. of roasted sulphides contained 42 per cent lead and bismuth by fire assay, besides 15.2 ozs. of silver and 1.6 ozs. of gold to the ton of material.

The basic chloride of bismuth was dried in iron kettles and the metal was obtained from it by melting in iron kettles with soda ash, potassium chloride, and charcoal.

The iron kettles used for this purpose were 22 ins. in diameter and 20 ins. deep and had a fairly flat bottom, slightly dished to the center.

One man and one helper could dry and melt in 3 kettles, operating them at the same time. A suitable charge for melting in one kettle was 40 lbs. basic chloride of bismuth, 6 lbs. potassium chloride, 12 lbs. soda ash, 58 per cent, and 8 lbs. of powdered charcoal.

In one instance, one man and one helper made in 8 working days, from 1672 lbs. basic chloride of bismuth, 252 lbs. potassium chloride, 504 lbs. soda ash, 58 per cent, and 336 lbs. powdered charcoal, a total of 1241 lbs. of bismuth metal, which by melting with $2\frac{3}{4}$ lbs. of caustic soda, 74 per cent, and $5\frac{1}{2}$ lbs. of potassium nitrate had been freed from arsenic.

In another instance, one man and one helper reduced, in 8 working days, 1229 lbs. of bismuth metal from 1612 lbs. basic chloride of bismuth, 240 lbs. potassium chloride, 480 lbs. soda ash, 58 per cent, and 320 lbs. powdered charcoal.

D. The extracted ore was dried on a heated floor. The coarse material and the slimes were kept separate, and after sampling the material was ready for shipment to the smelters.

By the process and with the plant described, about 1000 tons of ore were treated, and somewhat more than 60,000 lbs. of bismuth were extracted from the ore.

Table V gives a comparison of the cost of working ores, containing 2 per cent, 4.75 per cent and 6.26 per cent bismuth, respectively:

TABLE V

COST OF EXTRACTING BISMUTH FROM ORES BY DILUTED SULPHURIC ACID AND CHLORIDE OF SODIUM

Cost of treatment per ton of ore. St. Louis prices.

Average Quantities Used in Working Ore Lots Containing Varying Amounts of Bi.	113 Tons Dry Ore Containing 2% Bi.			44.5 Tons Dry Ore Containing 4.75% Bi.			235.5 Tons Dry Ore Containing 6.26% Bi		
	lbs.	cts.	$	lbs.	cts.	$	lbs.	cts.	$
Sulphuric acid 60° Bé..	1115	0.4	4.46	1101	0.4	4.40	1107	0.4	4.43
Chloride of sodium 90% inferior quality	1115	0.2	2.23	1101	0.2	2.20	1107	0.2	2.22
Caustic soda, 74%	44	2.4	1.06	82	2.4	1.97	89	2.4	2.14
Sulphur, flour.....	30	1.2	0.36	55	1.2	0.66	61	1.2	0.73
Time.....	.....	....	13.47	.....	....	15.67	.....	....	16.40
Coal for roasting, $1.50 per ton.....	1910	....	1.43	3240	....	2.43	3660	....	2.75
Sundries, repairs, steam	.....	....	5.00	.....	....	5.00	.....	....	5.00
Per ton of dry ore:									
Cost of treatment...	.....	....	28.01	.....	....	32.33	.....	....	33.67
Weight of chemicals.	2304	....	.....	2339	....	.....	2364		
Weight of coal	1910	....	.....	3240	....	.....	3660		

Table VI gives a comparison of the cost of treating 6.26 per cent ore in Leadville and in St. Louis:

TABLE VI

If the ore is treated in Leadville, where the tailings can be sold to the Leadville smelter, thus saving freight, the cost of extracting bismuth from 6.25% ore changes as follows:

Basis: Lot weighing 530,870 lbs. gross (wet).
471,138 lbs (dry).

Savings over St. Louis prices:	
Freight on ore to St. Louis	$2,256.20
Switching	53.08
Unloading	53.08
Purchasing expenses, two-thirds	200.00
Freight on tailings to smelter	464.15
	$3,026.51
Larger expenditures than in St. Louis:	
Freight on 278 tons chemicals, at $15.00	$4,170.00
Excess cost of 431 tons coal, at $1.50	646.50
	$4,816.50

These figures are in favor of St. Louis.

From Table V it is seen that the cost of extracting low-grade ore is less per ton of ore than the treatment of ore containing more bismuth. But the cost of extracting 100 lbs. bismuth from high-grade ore is much less than from inferior material.

Table VI shows that the cost of extracting bismuth ores is higher in Leadville than in St. Louis, principally on account of the freight charges on coal and chemicals.

Table VII gives a full account of the cost of treatment of a large large lot of 6.26 per cent ore, which may be considered typical for the average bismuth ores mined in Leadville, Colo. In examining the table, it will be observed that 1410.20 ozs. silver and 12.52 ozs. of gold were lost in the transaction, while $626.16 was obtained for 20,872 lbs. of lead for which no money was paid to the mine. Taking these three values together, the account stands, $15,255.44 paid out against $15,009.40 received, which is a minus of $246.04 on the lot. Out of the 29,503 lbs., which is equivalent to 6.26 per cent bismuth contained in the ore by analysis, only 22,436 lbs. were paid for, the difference of 7067 lbs., equal to 1½ per cent bismuth, having been deducted to compensate for treatment charges. But 23,403 lbs. of bismuth were extracted from the lot. This amounts to only 4.97 per cent. The tailings were carefully analyzed and a score of analyses proved them to contain from 0.25

TABLE VII

COST OF BISMUTH EXTRACTED FROM LEADVILLE ORES

Weight of ore, 530,870 lbs. gross (wet).
471,138 lbs. (dry).

Assay: Silver, 83.53 ozs. per ton; bismuth 6.26% in the dry ore.
Gold, 1.09 " "

Conditions of purchase: Silver paid for at 95% of New York market quotations; gold paid for at $19.40 per oz.; bismuth 1½% deducted from values found by wet analysis to compensate for treating charges, the rest to be paid for at the rate of 77.5 cents per pound bismuth in the ore. Freight to St. Louis paid by seller.

Values Contained in the Ore by Assay.	Values Paid for		
Silver ..... 19,679.00 ozs.	18,695.00 ozs.	$ 0.55	$10,282.25
Gold ..... 256.35 ozs.	256.36 ozs.	19.40	4,973.19
Bismuth ..... 29,503 lbs.	22,436 lbs.	0.77½	17,387.90
Lead, not ascertained	.....	.....	.....
Gross value of ore			$32,643.34
Less freight to St. Louis, $8.50 per ton			2,256.20
Value received by seller			$30,387.14
Expenses:			
Freight to St. Louis		$2,256.20	
Switching, at 20 cents per ton		53.08	
Unloading, at 20 cents per ton		53.08	
Sampling, $1.00 per ton		265.50	
Assaying		60.00	
Purchasing expenses		300.00	2,987.86
Cost of 471,138 lbs. dry ore at St. Louis		.....	33,375.00
Treatment for bismuth, $33.67 per ton		.....	7,931.58
Freight on 437,991 lbs. tailings to smelter		.....	464.15
Treatment charges on same		.....	2,097.91
Total expenditures		.....	$43,868.64
Receipts from smelter:			
For silver, 17,284.80 ozs., 55 cents		$9,506.64	
For gold, 243.83 ozs., $20.00		4,876.60	
For lead, 20,872 lbs., 3 cents		626.16	15,009.40
Cost of 23,403 lbs. bismuth, 123.3 cents per lb. ...		.....	28,859.24
Paid for 22,436 lbs. bismuth, 77.5 cents per lb. ...		.....	17,387.90
23,403 lbs. bismuth extracted at 49 cents per lb ..		.....	$11,471.34

The cost of extraction was 49 cents per pound of bismuth.

Since the market price of bismuth was $1.85, there was a gross profit of 61.7 cents per lb. of bismuth, equal to $14,419.65 on the lot.

to 0.35 per cent of bismuth. There was no material loss in working and there were no errors in analyses, to the best of my judgment. The only conclusion remained that the average samples by which the ore was bought did not represent the true average, but showed more bismuth than the ore actually contained.

The weight of the tailings, namely, 437,991 lbs., would seem high, but it must be considered that iron and alumina were rendered insoluble by roasting and that the weight was increased by the flue ashes in the roasting furnace. They also contained some sediment from the refuse liquors from chlorine stills which were used in place of sulphuric acid, 60° Bé., and were calculated at the value of free acid contained in them.

In the calculation given in Table VII, no charge is made for interest on capital invested, insurance and devaluation on the plant, but the gross profit made on the lot would seem sufficiently high to justify even an expensive plant, including labor-saving machinery, provided a regular supply of ore and a steady market for bismuth can be arranged.

The plant was in successful operation for more than a year. Then all of a sudden the bismuth ores in the mines were reported exhausted. The plant burned down and was not rebuilt. Later on I was told that bismuth ores were mined the same as before but that they were taken up by the smelters and that the bismuth was wasted.

There is no tariff on bismuth, neither is there any duty on bismuth ore. One-third of a million dollars annually go to England which might be kept in this country if bismuth metal and bismuth ores were properly protected by tariff. Bismuth ore is one of the natural resources of the United States and, in my opinion, our Government should see that it is not wasted.

THE CLASSEN LIGNUM CO.

On April 18, 1903, there was submitted to me a circular issued by ..... bankers in New York, Chicago and St. Louis, offering 5000 shares of 7 per cent cumulative preferred stock of the Classen Lignum Co. at par, each share of preferred stock to receive one share of common stock as a bonus.

The total capitalization of the company was $2,500,000, divided into $600,000 of 7 per cent cumulative preferred stock and $1,900,000 of common stock.

Everything was in readiness to put the stock on the market, but before doing so the bankers submitted to me a full typewritten statement of forty pages, setting forth the nature of the process as described by the inventor, and a number of reports on its working, made by chemists of reputation, on the strength of which subscriptions were to be solicited on the stock market five days hence.

I was requested to make a final comment on the proposition and complied with this request two days later, on April 20, 1903.

Dr. A. Classen, of Aachen, Germany, described his process as follows: The object of the process was to turn sawdust into valuable products, and the Classen Lignum Co. proposed to work the large accumulations of sawdust in the northwestern lumber districts of the United States. The Classen process utilizes the action of sulphurous acid upon wood, which is a dissolving action without converting it into glucose. Subsequently, the surplus acid is oxidized to sulphuric acid by the oxygen of the air, and the sulphuric acid thus produced converts the soluble cellulose into glucose of a quality which is readily converted into alcohol by fermentation.

The insoluble part of the sawdust, which is called the tailings and consists of about three-quarters of the original weight of the sawdust used, is pressed into briquettes, from which, by dry distillation, wood tar, methyl alcohol, acetone, acetate of lime, and charcoal are obtained, and as an important feature of the process, it was taken into account that the products from the tailings would not only pay the cost of the sawdust and of the entire Classen process, but would moreover yield a fair profit by themselves. The calculation of cost and probable profits of these by-products was among the papers submitted to me. To this I shall refer later on.

In two experimental plants at Aachen and Chicago, the alcohol part of the process was tested by experiments of many months' duration. It was proven that the product was really alcohol, but no figures were given which could prove anything about its cost. By guesswork the conclusion was reached that the manufacture of alcohol from sawdust would not cost more than the manufacture of alcohol from grain.

This conclusion seemed entirely satisfactory since the calculation of the by-products was showing for itself a large profit, and was expected to carry the process to a successful end. Full reliance was placed upon the judgment of the men who had conducted the tests, and to secure public confidence in the proposition, the full titles

and honors of those engaged in the investigation were given for the purpose of characterizing the men who were recommending subscription to stock in the company.

In such condition the reports came to me. There was no time to repeat experiments, since the paper was ready to be put on the market. Moreover it was likely that the experiments were correctly conducted since chemists of good reputation had signed their names to the reports, but some of these chemists were men of science and for this reason the calculations seemed to require my attention.

The only calculation in the report was for the by-products and it was made for European conditions. It had not occurred to any one of the investigators that the same calculations might not apply to an American plant. I made a calculation for American conditions, based upon the same figures for weights and quantity, time and materials, which were used in the European calculation by constructing the table given below, in which is seen a comparison of the rentability of the process in Europe and in the United States.

This Table (Table I) I submitted with the following comment:

Line 1. The price of 4 Pf. per kilogram, or 10 cents per bushel for charcoal may be right for Europe, but is entirely too high for the United States. I was buying at that time single car-load lots at 6 cents per bushel, f.o.b. place of production, and since it was proposed by the Classen Lignum Co. to use the charcoal for blast furnaces, even 6 cents would be prohibitive, and it was believed that not more than 4–5 cents could be obtained at that time. Figuring 5 cents would reduce the income from charcoal to one-half.

Line 2. Calcium acetate, 80–82 per cent, was valued at $1\frac{1}{2}$ cents per lb. This was entirely too high. As a matter of fact, at that time, a great surplus of acetate of lime was manufactured in the United States and exported to Europe, where it was sold at $1\frac{1}{2}$ cents per lb., but this included the freight from the place of production to European markets and included also the profits of a firm in New York, which had monopolized the article, so that the manufacturer in Michigan at that time received less than 1 cent per lb. for his product. As a matter of fact, the price of acetate lime, 74 per cent, f.o.b. place of production in Michigan, had not been higher than 0.8 cent for ten years. This caused another reduction in the receipts of the proposed works.

Line 3. It is true that the nominal value of wood spirits in the United States at that time was 65 cents per gal., but the price actually

Table I

ESTIMATE OF PROSPECTIVE PROFITS ON WORKING 25 TONS TAILINGS A DAY FROM CLASSEN'S ALCOHOL PROCESS BY HEIDENSTON'S PATENT

Receipts

	For Europe.		For the United States.	
	Marks.	Marks.	Dollars.	Dollars.
1. Charcoal. . . 12,000 kilograms	0.04	480.00	....	.....
1. Charcoal. . . . 1,200 bushels	....	.....	0.05	60.00
2. Calcium acetate 80/82 575 kilograms	0.15	86.25	....	.....
2. Calcium acetate 80/82 1,265 pounds	....	.....	0.01	12.65
3. Wood alcohol 87.5 kilograms	0.70	61.25	....	.....
3. Wood alcohol 28 gallons	....	.....	0.50	14.00
4. Pine tar. . . . 1,250 kilograms	0.10	125.00	....	.....
4. Pine tar. . . . 1,250 kilograms	....	.....	0.00	.....
5. Total per day	....	752.50	....	$86.65
6. For 300 working days	....	M. 225,750.00	....	$25,995.00

Expenditures

7. 25 tons sawdust	2.00	M. 50.00	....	.....
7. 25 tons sawdust	....	.....	0.50	12.50
8. 15 tons sawdust, for fuel	2.00	30.00	....	.....
8. 15 tons sawdust, for fuel	....	.....	0.50	7.50
9. 40 shifts' wages of 12 hours each	3.00	120.00	....	.....
9. 40 shifts' wages of 12 hours each	....	.....	1.50	60.00
10. Total per day	....	200.00	....	80.00
11. For 300 working days	....	60,000.00	....	24,000.00
12. Superintendent per year	....	2,000.00	....	2,000.00
13. Expenses, taxes, insurance, storing	....	15,000.00	....	7,500.00
14. Lime and sundry materials	....	6,500.00	....	2,000.00
15. Sundries and repairs	....	10,000.00	....	2,500.00
16. Patent license	....	10,000.00	....	2,500.00
17. Devaluation on machinery and buildings, 10% on M. 278,500	....	27,850.00	....	.....
18. Do. 10% on $125,000	....	.....	....	12,500.00
19. Interest, 5% on M. 320,000	....	16,000.00	....	.....
20. Interest, 5% on $150,000	....	.....	....	7,500.00
21. Total expenditures	....	M. 147,350.00	....	$60,500.00
22. Total receipts	....	M. 225,750.00	....	$25,995.00
23.	Profit	M. 78,400.00	Loss .	$34,505.00

received by the manufacturer was much less, since the American market at that time did not absorb more than half of the production.

The price for the whole consumption was kept up artifically by an American syndicate and the surplus was exported to foreign markets. In my opinion, not more than 50 cents per gallon could be obtained, which makes another reduction in the receipts of the proposed works.

Line 4. 1250 kilograms of pine tar were valued at 125 M. While pine tar in Germany may have this value, it has no value at all in this country. In Europe it is used for painting sheds and cheap buildings, but in the United States nobody would think of using pine tar for this purpose. The odor imparted to the buildings by this paint is of such a character that no American would live in buildings painted with it. In reality, all the American charcoal works allow the pine tar to go to waste, or use it for fuel, and there is no value in it.

Line 9. The wages for every 12-hour shift were figured at 3 M. or 75 cents. This was too low. No laborer in the United States would work 12 hours for less than $1.50.

Line 12. The manager who is at the head of works, costing about $125,000, could not be had for a salary of 2000 M. or $500 a year. $2000 a year would be a small salary for an efficient man.

Line 13. The rate of insurance in the lumber district being 3 per cent would amount to $3,750, and an equal amount for general expenses, bookkeeping, stationery, postage, storage, and taxes is none too high.

Line 14. Lime and other materials are very high in the Northern States, and $2000 in place of 6500 M. is very low figuring.

Lines 17 *and* 18. The buildings and machinery, the cost of which is estimated at 278,560 M. under European conditions, cannot be erected in the United States for less than $125,000 and 10 per cent devaluation on this amount will add $12,500 per year to the expense account. To run the works, at least $25,000 working capital would be necessary, which makes the entire capital used for the plant, $150,000, the interest of which at the rate of 5 per cent, equal to $7500, must be added to the expense account.

The result of the comparison was that there would be a probable yearly loss of $34,505 for an American plant, against a yearly profit at 78,400 M. for a plant of the same description operated in Europe.

This argument made up on the short notice of one day and submitted to the interested parties caused the prompt withdrawal of

the entire proposition, rendering valueless the expert examination of many months considered necessary by scientific chemists, and saved a large sum of money to easy investors.

THE PLANT OF THE KENTUCKY SODA ASH CO.

In April, 1892, I was approached by a syndicate of about twelve prominent men of the highest standing in the City of Louisville, Ky., to assist them in the erection of ammonia soda works. They were desirous of drawing that industry to the neighborhood of their home city, since near Brandenburg, Ky., about forty miles distant from Louisville, salt works had been operated for a long period of years with natural gas as fuel, which was emanating from the salt wells, together with the brine. In their opinion this occurrence of natural resources could be the foundation of a soda ash industry.

They had the capital, had secured detailed information about the ammonia soda process, and had a man among their number, whom they thought capable of serving as a foreman to run the works. Realizing that the ammonia soda process is largely a process involving the handling of ammonia, they came to me as an experienced ammonia maker, to assist them in the construction of the works.

On the Mooreman farm, near Brandenburg, Ky., salt works had been operated for many years. There were two or three wells, which had supplied the works with salt brine and natural gas.

Since the production of salt had been limited, I had some doubts whether the available quantities of brine and gas would justify the erection of a large plant in that locality, and wrote before commencing work on the plant, on May 5, 1892, to the Kentucky Soda Ash Co. as follows:

" I do not believe that it is advisable to start with the soda ash works before you have proven beyond doubt that you have salt and gas of good quality and that you have plenty of it. Cheap salt and fuel is the great advantage of your enterprise, and before you spend any money on the soda plant you should be perfectly sure of the first part. If you first sink salt wells and find no sufficient supply, you lose only the money for the wells. If you first build the soda works, sink the wells afterwards and find no supply of salt, then all your expenditures will be a clear loss."

To this I received the reply, that they knew their territory and

were willing to take the risk. Moreover they considered the erection of a 10-ton plant in the nature of an experiment, and would erect a very much larger plant on a different site—possibly in the neighborhood of Detroit, Mich., if the supply of raw material should fail. Their principal aim was to demonstrate that they could make soda ash of good quality and at low cost, and they had decided to make the experiment in their locality.

With this understanding I consented to construct a plant for them and in doing so I directed the construction of the apparatus to the minutest detail, going to many expenses, which were justified only, if the plant was to be an experimental works as a forerunner to a larger plant.

Under these conditions, a plant capable of making 10 tons of soda ash per day of 24 hours was erected, and I will state right here, that when completed it started running without a hitch and in a three months' run demonstrated the successful operation at a low cost. But after three months the salt wells were exhausted and needed a rest of several months before they could be operated again, and it was necessary to shut the works down. In the meantime the financial crisis of 1893 had set in and had swept away the fortunes of some of the stockholders, and the plans for erecting a larger works could not be carried out. So the enterprise came to a termination by the Kentucky Soda Ash Co. going out of business.

Since all of the plans were carried out in great detail they well may serve as an example of how a problem of chemical engineering may be solved, and for this purpose only, I have selected some of the work for presentation in this meeting.

You all know the chemical reactions underlying the ammonia soda process. For this reason it is not necessary to lose time in stating them.

The apparatus necessary for the process may be divided into the following groups, if brine, limestone and ammonia are given as raw materials:

First. Lime kilns and carbonic acid washers to make carbonic acid and caustic lime.

Second. Apparatus for making bicarbonate of soda and converting this into carbonate of soda.

Third. Apparatus for slaking lime.

Fourth. Apparatus for recovering ammonia.

Following this introduction a line of 65 lantern slides were pro-

jected on the screen with a view of giving one way in which the ammonia soda process might be demonstrated to advanced students in a lecture room. A number of these slides have been reproduced and will be found at the close of the article.

The first four slides represented apparatus assembled in the four great divisions of an ammonia soda plant as enumerated above.

Such a division is most desirable in order to facilitate the understanding of the entire and very complicated plant.

Slides Nos. 5-65 gave detailed drawings and models of some of the important parts of the plant.

The following list gives a more complete idea of what was offered:

1. Lime kilns and carbonic acid washers to make carbonic acid and caustic lime.

2. Apparatus for making bicarbonate of soda and converting this into carbonate of soda.

3. Apparatus for slaking lime.

4. Apparatus for recovering ammonia.

5. Drawing of lime kiln.

6. Drawing of carbonic acid washer.

7. Drawing of column, general view.

8. Drawing of base of column.

9. Drawing of bottom of column.

10. Drawing of bottom section of column.

11. Drawing of dividing plate of column.

12. Drawing of center section of column.

13. Drawing of cooling section of column, outside view.

14. Drawing of cooling section of column, inside view.

15. Drawing of top section of column.

16. Drawing of cover of column.

17. Drawing of bolts for column.

18. Drawing of gaskets for column.

19, 20 and 21. Wooden models representing the parts of the column on the scale of 1 in. to the foot.

22. Drawing of vacuum filter.

23. Drawing of vacuum filter, displayed.

24. Drawing of roasting apparatus.

25. Detail drawing of same.

26. Top view of same.

27. Detail sheet of machinery on same.

28–29. Wooden model of roasting apparatus.
30. Drawing of ammonia still, general view.
31. Drawing of ammonia still, lower half.
32. Drawing of ammonia still, boiler iron work.
34. Drawing of ammonia still, bottom piece.
35. Drawing of ammonia still fittings.
36. Drawing of ammonia still, reducing piece.
37. Drawing of ammonia still, dividing bottom.
38. Drawing of ammonia still, top section.
39. Drawing of ammonia still, dividing bottom.
40. Drawing of ammonia still, cross-section of same.
41. Drawing of ammonia still, drip plate.
42. Drawing of ammonia still, cover.
43–52. Wooden models made on the scale of 1 in. to the foot, representing parts of the ammonia still.
53–58. Detail drawings of absorbers.
59–65. Detail drawings of coolers.

All slides were made from good working drawings from which the actual plant was constructed. In order to convey the meaning of the drawings more clearly to the pattern makers and to facilitate the arrangement in space of all the apparatus, complete models were made on a scale of 1 in. to the foot, and as an example three pictures of the models for the column are given in the accompanying cuts, Figs. 15, 16, 17.

In the experience of the writer such models have been of great service in securing the construction of chemical apparatus in conformity with drawings, particularly if they had to be made in machine shops where the construction of chemical apparatus is new, or done only at great intervals.

It also is thought that models similar to the ones presented are highly instructive for students in chemical engineering. It is true that students even if they are highly advanced in manual training could not make such models themselves, since it takes the best of pattern makers to do that class of work. But it would pay well for any university to have a shop and to employ one or more pattern-makers steadily to do such work. By so doing they might accumulate in time a stock of models, the manufacture of which will serve to train the instructors, while the models themselves will be a lasting aid in the instruction of students.

Two columns were actually constructed by these drawings and

models. Each column was made up, as shown in Figs. 15, 16, 17, of 1 base, *A*; 1 bottom piece, *B*; 1 bottom section, *C*; 17 cooling sections, *D*, alternating with 16 center sections, *E*; 35 dividing bottoms, *F*, cast together with perforated plates, one bottom being located between each pair of sections; 3 top sections, *G*; and 1 cover *H*.

The entire finished weight of one column was 177,570 lbs. and it was constructed for $3\frac{1}{4}$ cents per pound of machined castings, the price being understood free on board cars at place of manufacture.

Specifications as actually used in construction of the apparatus accompanied the drawings, and the paper gave a full account of the construction and cost of a 10-ton ammonia soda plant.

It not being feasible to reproduce all of the drawings of the entire plant, from which a selection was given in the slides, only fourteen drawings are reproduced, three of which are diagrammatic to show the general arrangement of apparatus in an ammonia soda plant and eleven giving the detail construction of the column.

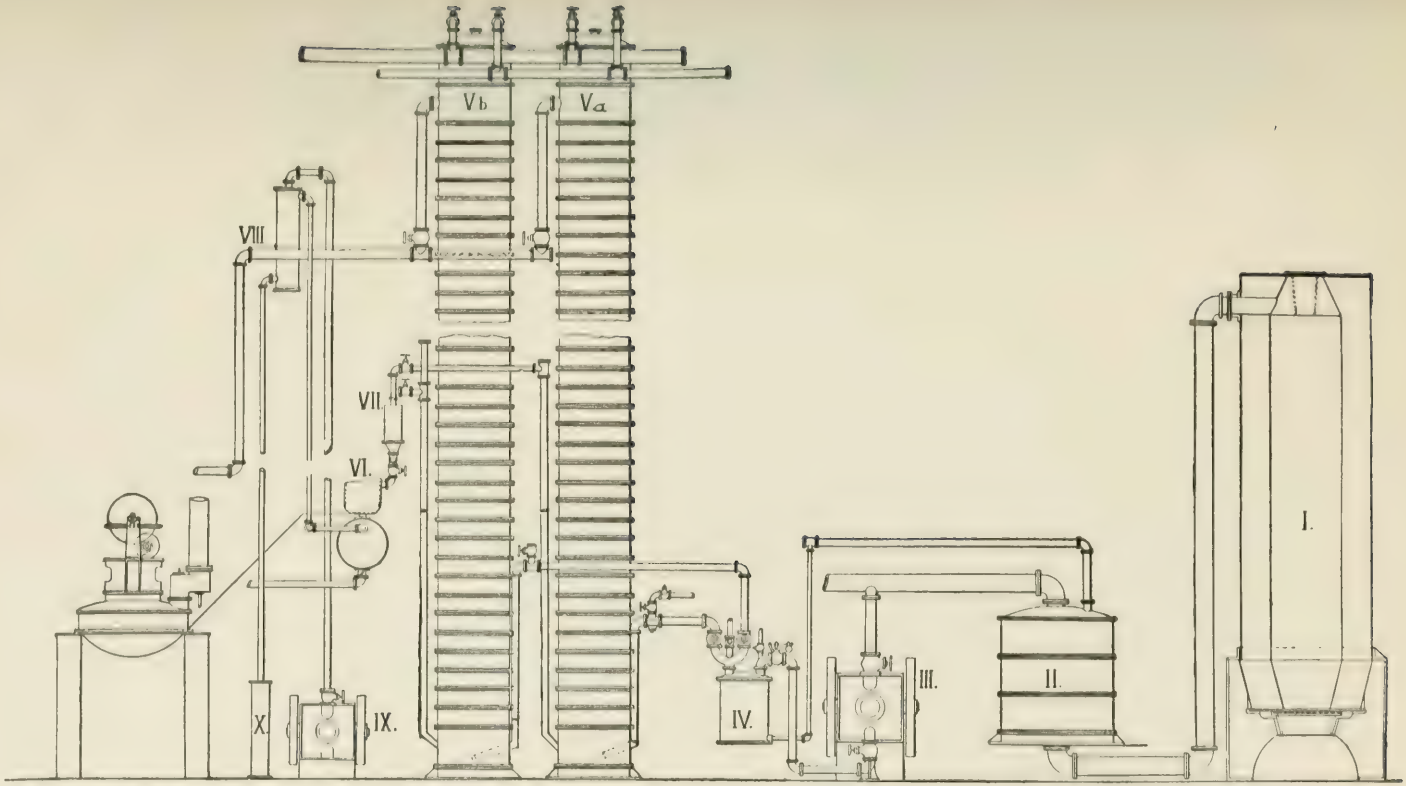


Fig. 1.—Diagram, showing general arrangement of apparatus for making soda by the ammonia soda process. I. Limekiln; II. Carbon dioxide washer; III. Carbon dioxide pump; IV. Drip; V^a and V^b Columns; VI. Vacuum filter; VII. Charging funnel for VI; VIII. Vacuum vessel; IX. Vacuum pump; X. Water seal. Roasting apparatus to the extreme left.

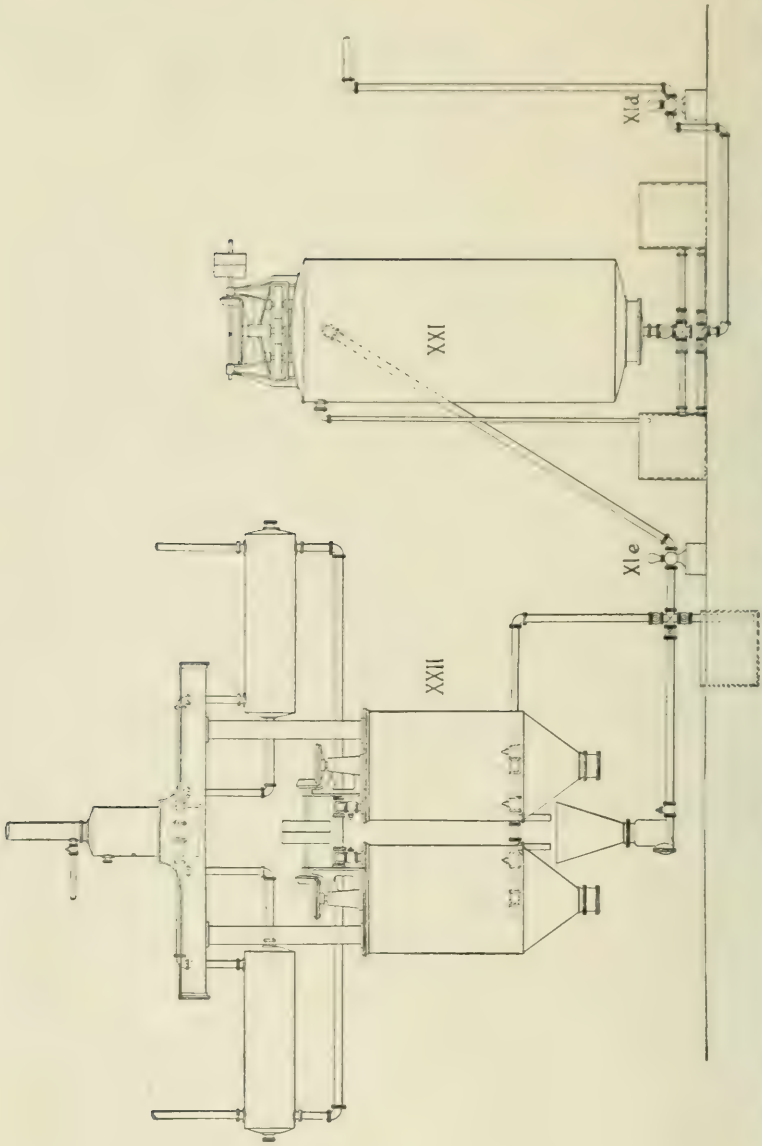


Fig. 2.—Diagram of apparatus used for making milk-of-lime. XI^{d} and XI^{e}. Pumps for milk-of-lime; XXI. Tank for storing milk-of-lime; XXII. Vessels for slaking lime.

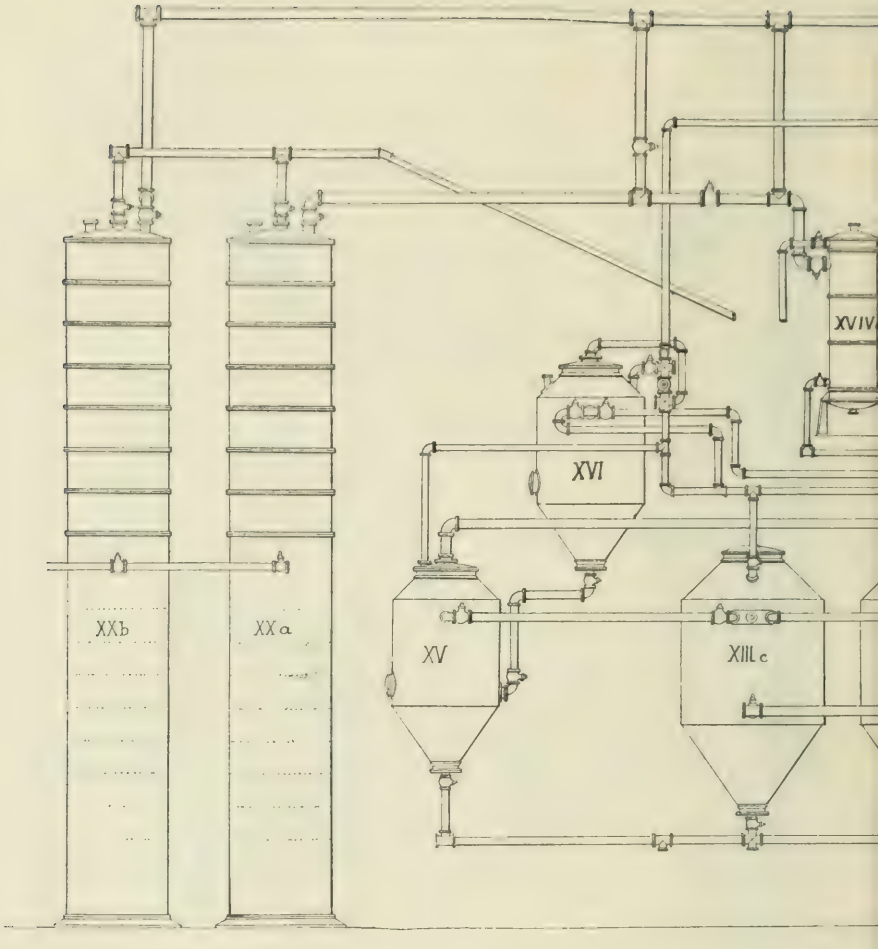
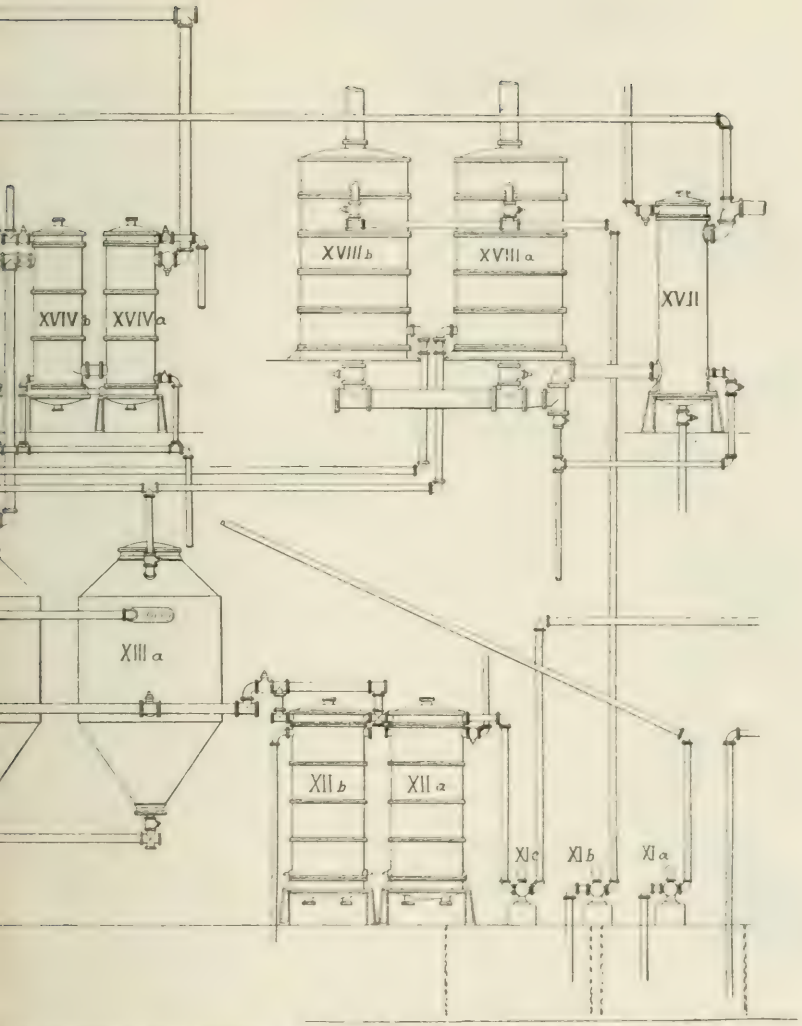


Fig. 3.—Diagram showing general arrangement of apparatus for recovering ammonia
XIII^a, XIII^b, XIII^c, Settling tanks; XV and XVI, Absorbers; XVII. Cooler; XV



the ammonia soda process. XI^{a}, XI^{b}, XI^{c}, Pumps; XII^{a} and XII^{b}, Coolers; d XVIII^{b}, Absorbers; XIX^{abcd}, Coolers; XX^{a} and XX^{b}; Ammonia stills.

[*To face page 122*

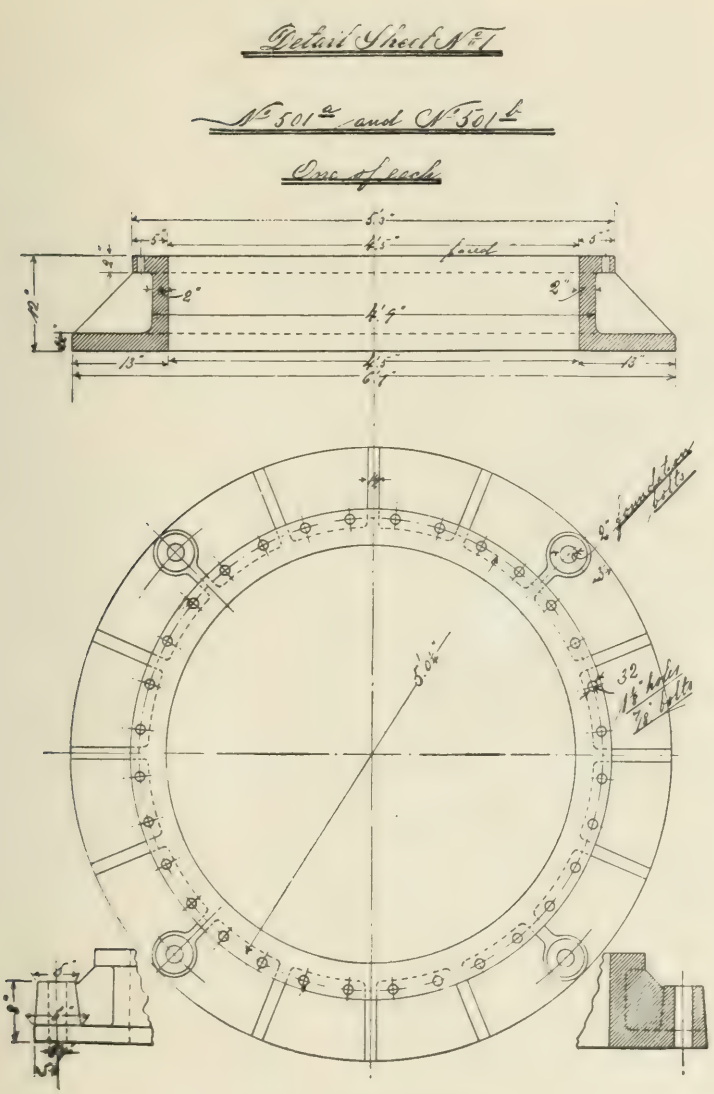


Fig. 4.—Foot of Column.

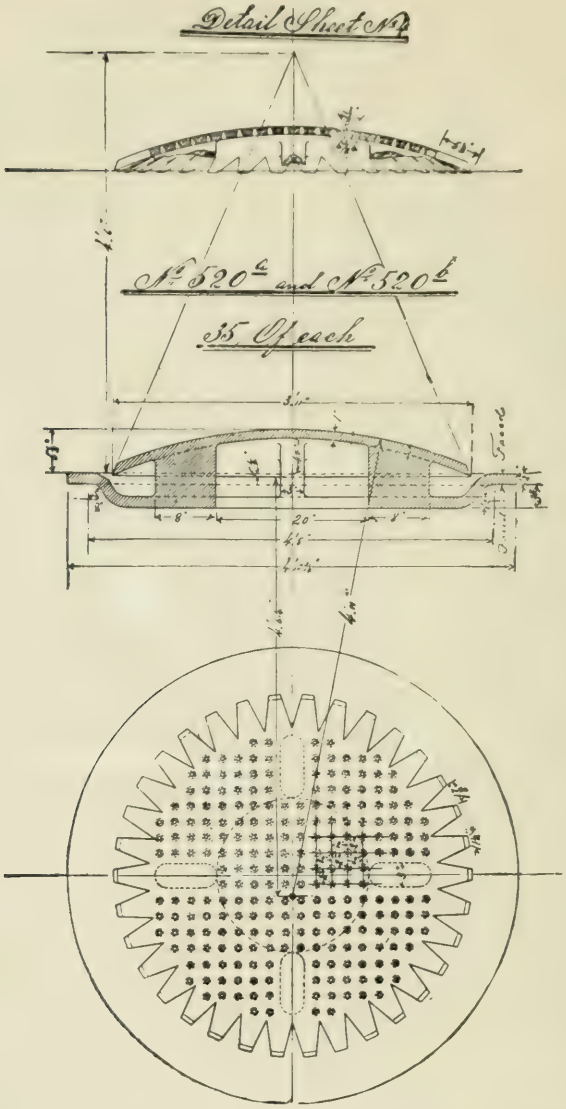


Fig. 7.—Dividing Plate Going Between Sections of Column.

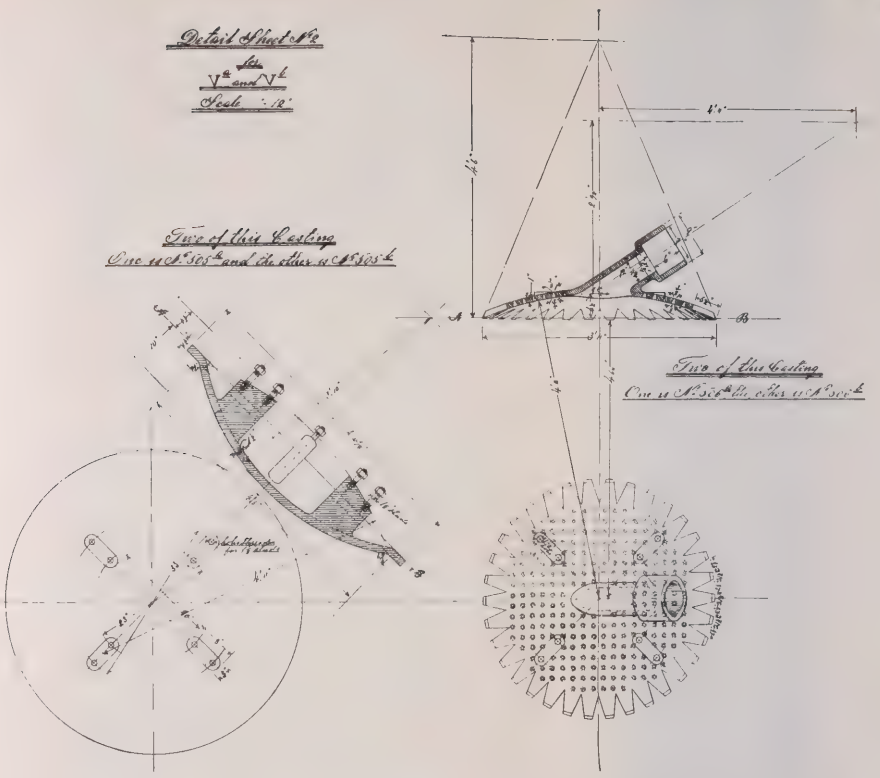

Detail Sheet N°2
Scale
V^te and V^te
Scale : 12"
Two of this Casting
One is N° 365 and the other is N° 365 bis
Two of this Casting
One is N° 365 the other is N° 365 bis

Fig. 5.—Bottom Piece and Distributing Star for Column.

[To face page 124]

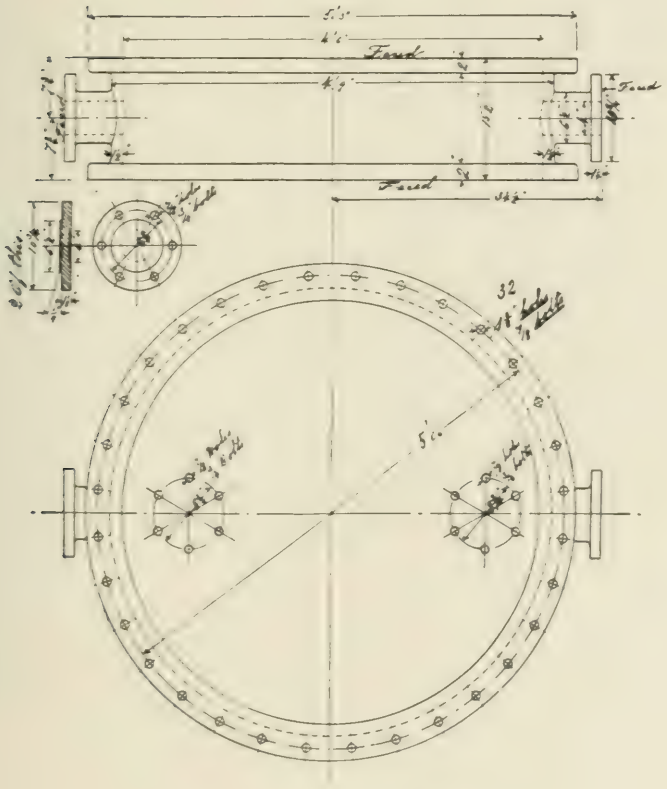


Fig. 8.—Center Section of Column.

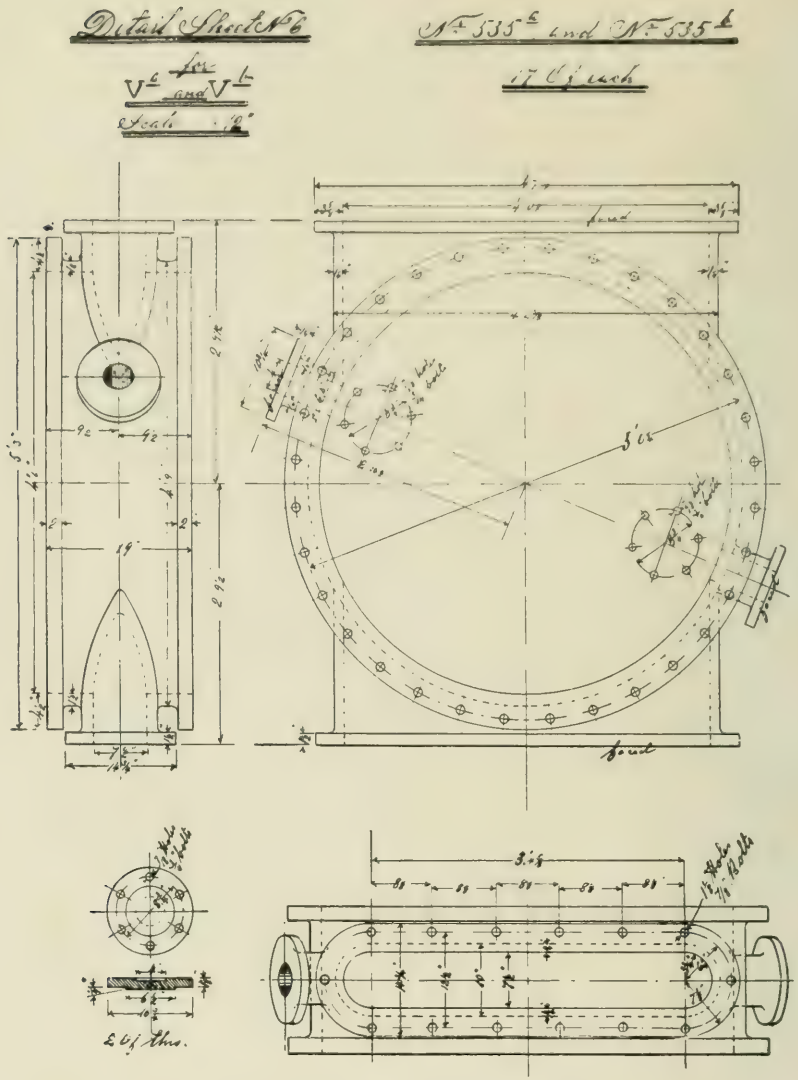


Fig. 9.—Cooling Section of Column.

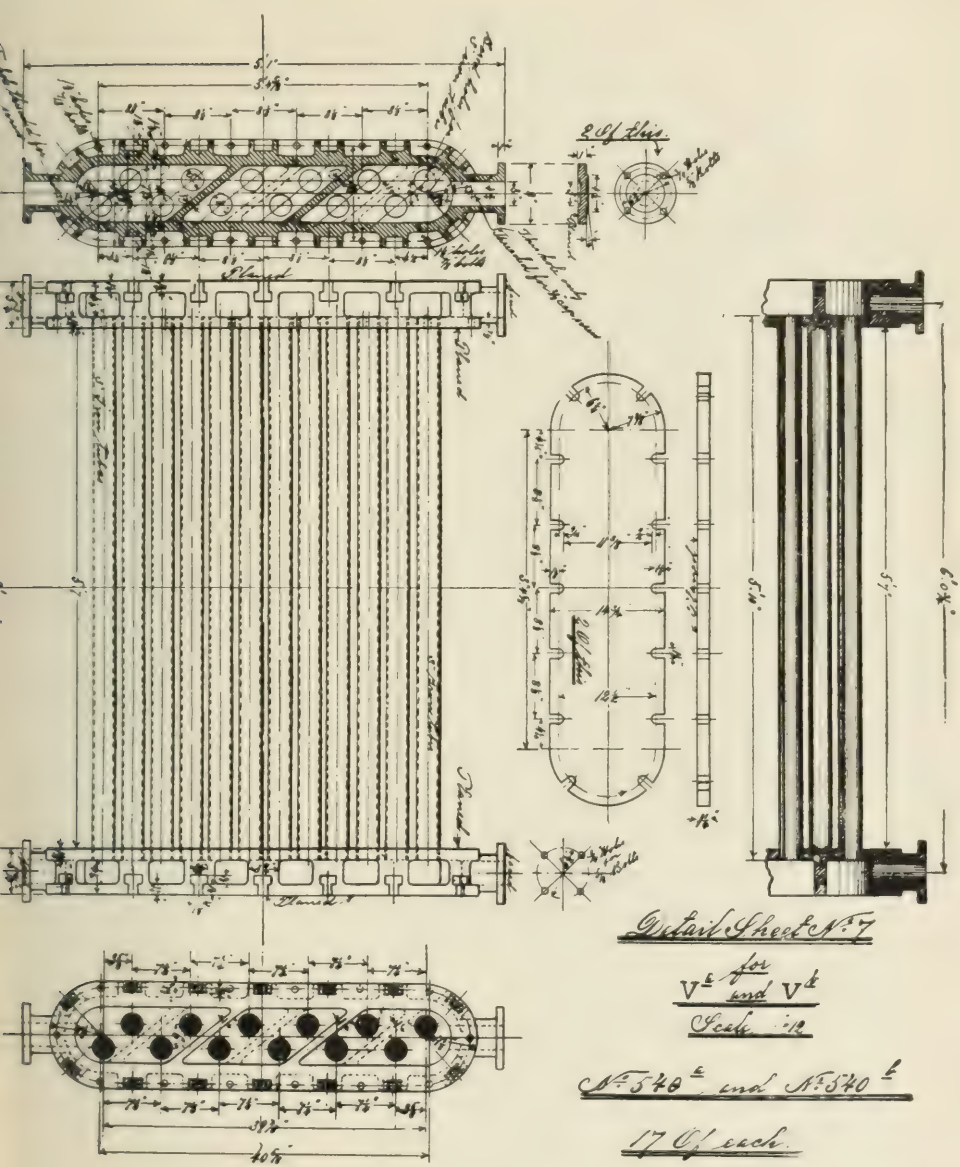


Fig. 10.—Water Pipes in Cooling Section of Column.

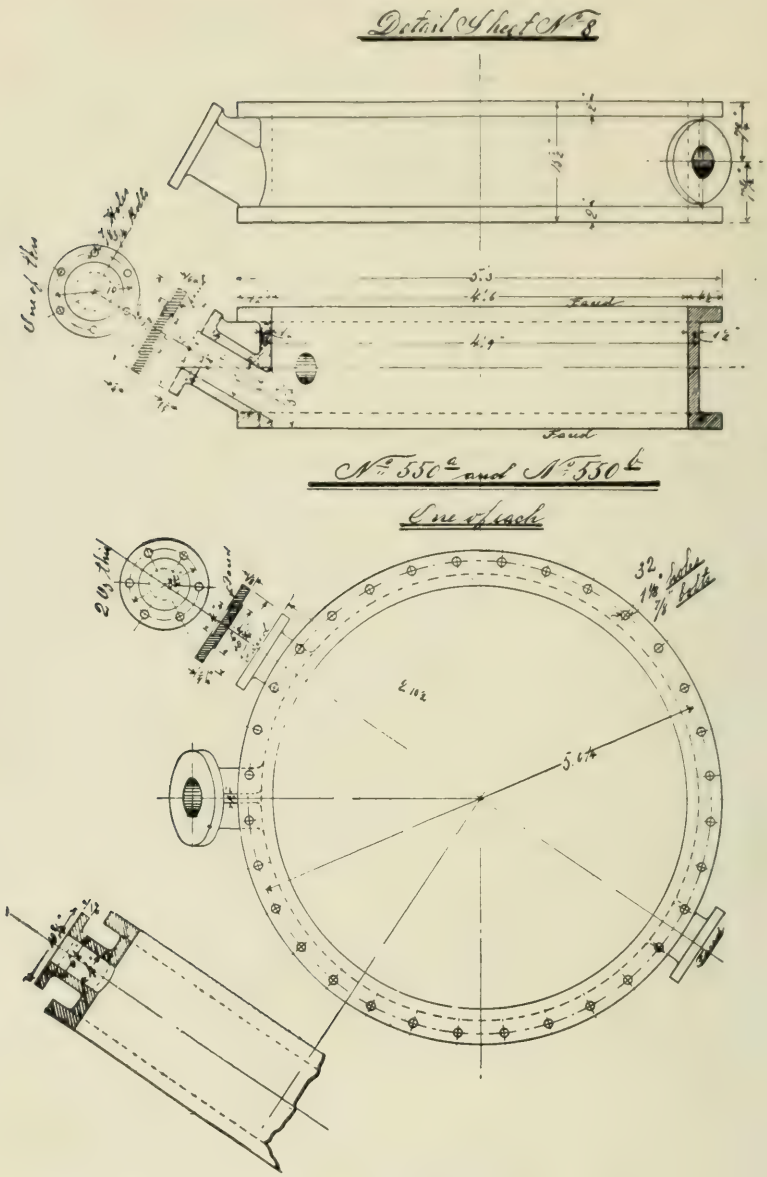


Fig. 11.—Center Section of Column with Side Outlet.

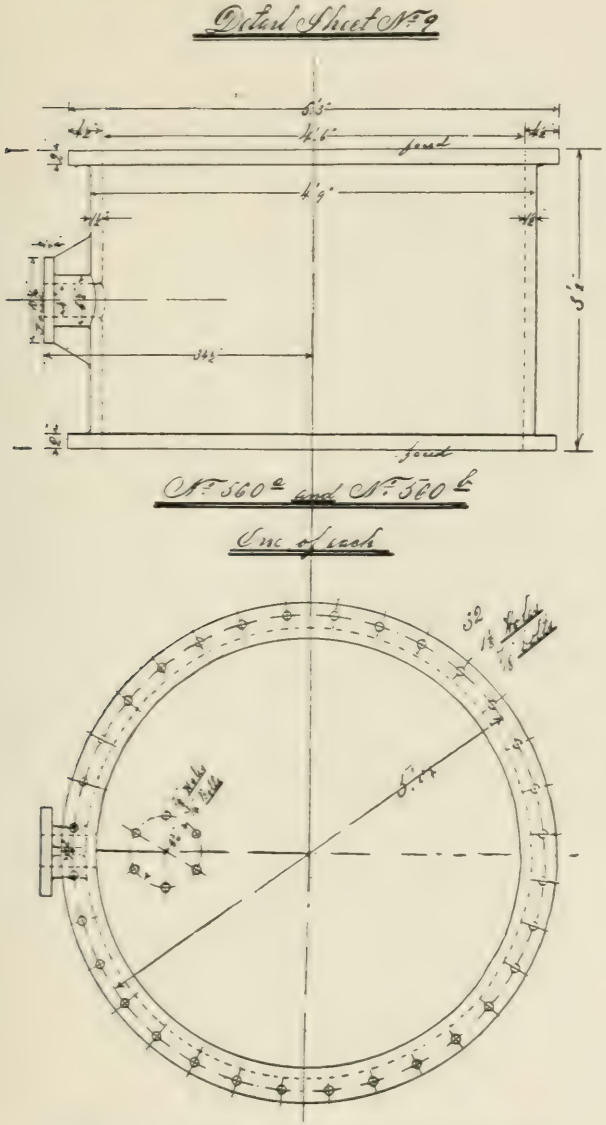


Fig. 12.—Top Section of Column with Side Inlet.

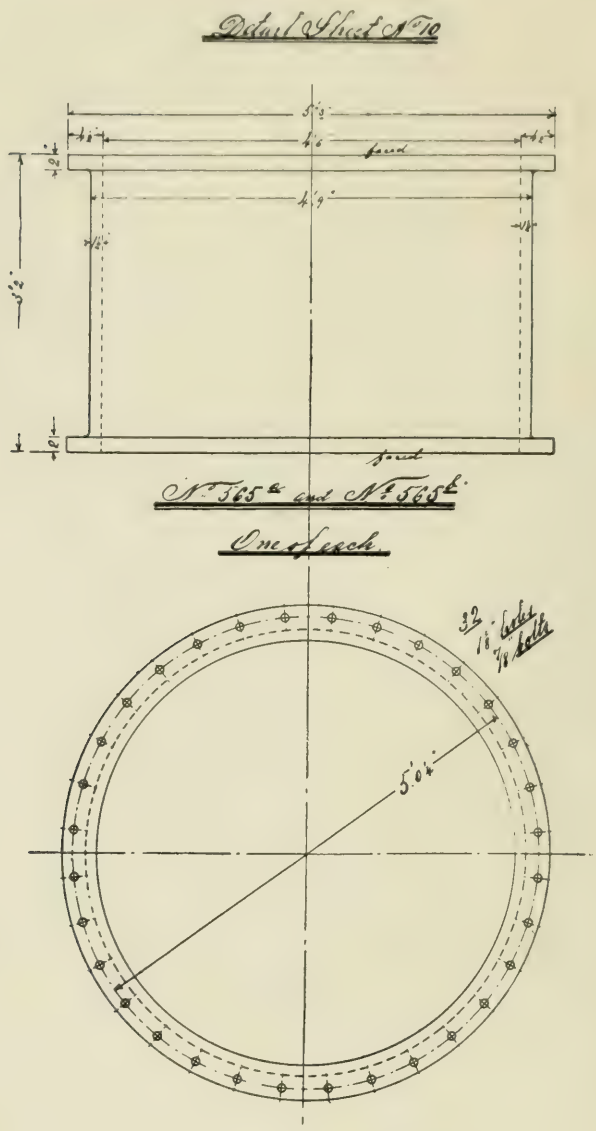


Fig. 13.—Top Section of Column.

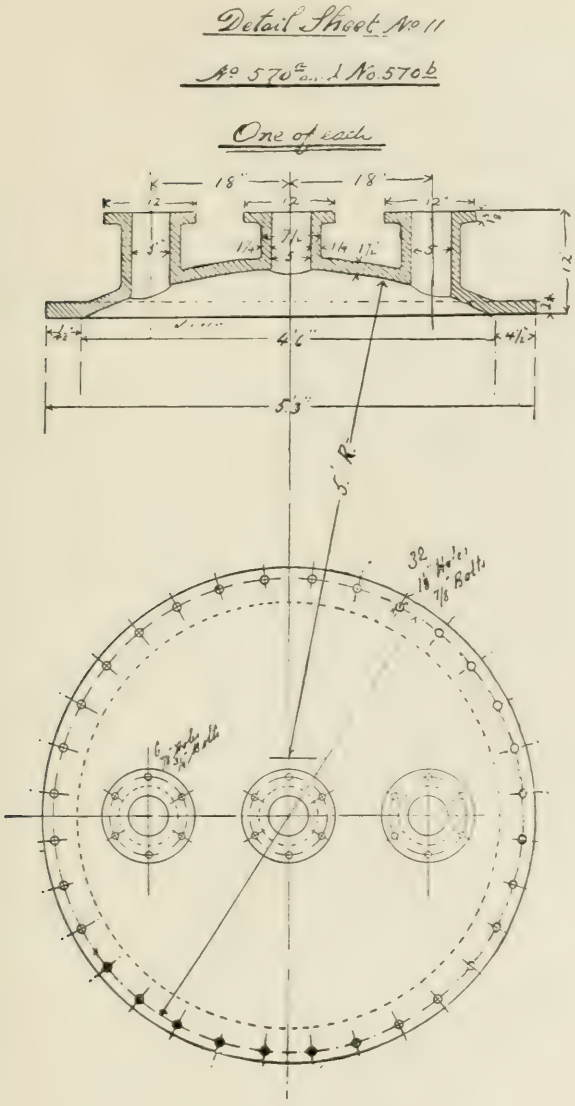


Fig. 14.—Cover of Column.

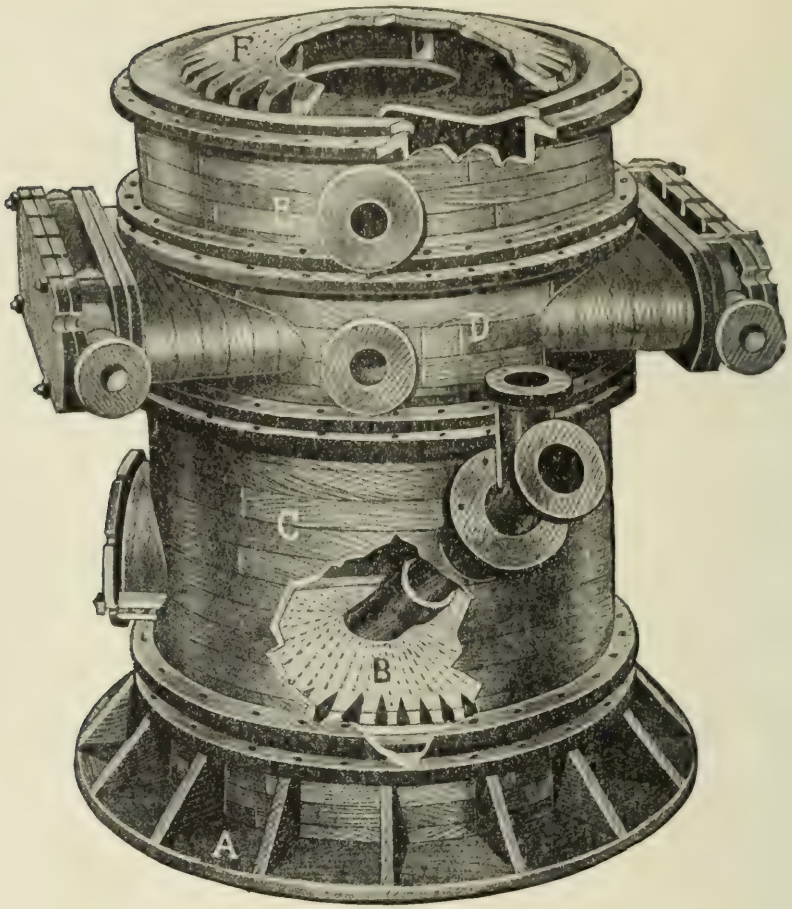


Fig. 15.—Wooden Model of Column. A. Foot; B. Bottom piece and distributing star; C. Bottom section; D. Cooling section; E. Center section; F. Dividing plate between sections.

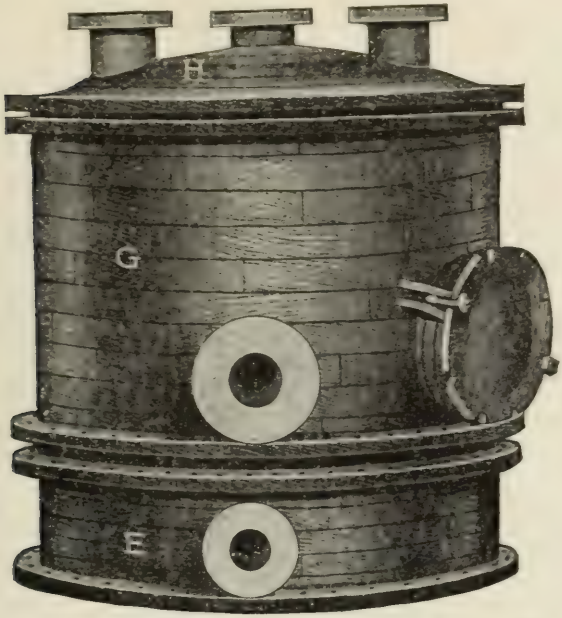


Fig. 16.—E. Center Section of Column. G. Top Section: H. Cover.

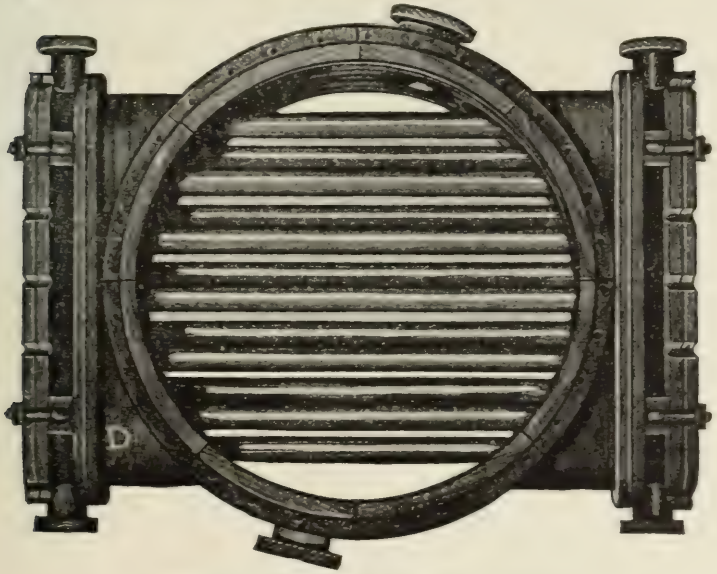


Fig. 17.—D. Cooling Section of Column.

SOME PROBLEMS IN CHEMICAL ENGINEERING PRACTICE

By President F. W. FRERICHS

INTRODUCTION TO WASHINGTON ADDRESS

Read December 20, 1911

ENCOURAGED by some of my friends, I offer to-day what may be called a continuation of the address which I delivered in Chicago, six months ago, and which is already published in the October and November issues of the Journal of Industrial and Engineering Chemistry.

For to-day, I have selected three problems in Chemical Engineering practice, the characters of which are widely different from the problems treated in June, and which give additional proof of the statement that the field of Chemical Engineering is exceedingly varied and difficult to define. Again, these problems are selected with a view to giving the student of chemical engineering an idea of the variety of questions with which he may be confronted but, at the same time, they are chosen to call attention to the wide difference between scientific chemical research and the investigation of chemical engineering problems.

Scientific research treats principally with reactions which produce definite substances and which can be expressed by chemical formulae and reactions.

Chemical engineering problems are based on reactions also but they include cost, quality, yield, labor, and safety of those engaged in the manufacture of goods, and provide for the convenience in handling the goods by the consumer. In the manufacture of chloroform from bleaching powder and ethyl alcohol, the process was known, but the object of the research was to find the conditions under which the maximum yield could be obtained by a known reaction and to construct apparatus which would give these conditions with greatest economy. In the construction of laboratory apparatus referred to, the saving of time affected by the improved apparatus was the leading element. In the manufacture and testing of shipping

cylinders for liquefied ammonia gas, the safety of handling and the convenience to the consumer was the object of the investigation.

These, together with the three problems treated in June, give only a few forms of the great variety of demands which are likely to be made on the Chemical Engineer and I should feel highly gratified if I have given an incentive to others of our members to follow in this direction, by giving the solution of additional cases, so that we may obtain a large variety of solved problems by which the students in our profession may be guided in their work.

THE MANUFACTURE OF CHLOROFORM FROM BLEACHING POWDER AND ETHYL ALCOHOL

As an example of improving an established process of manufacture, I have selected some work which I did about thirty years ago in connection with the manufacture of chloroform. At that time chloroform was made from tax-paid alcohol and bleaching powder. The acetone process was then little known but was developed about five years later superseding the alcohol process on account of its greater cheapness. But since we now have tax-free alcohol for manufacturing purposes, the old process has gained interest again, and this is one of the reasons why I have looked up old records in order to show what can be done with the alcohol process.

In the year 1883, I was in charge of a chloroform plant, comprising six cylindrical stills standing on end, each still being 6 ft. in diameter and 8 ft. high. Each still was connected with a condenser consisting of a lead coil and a receiver to catch the resulting chloroform. A flat iron box, to mix the bleaching powder with water, was over each pair of chloroform stills. The general arrangement of the apparatus was as given in Fig. 1.

The apparatus was operated in the following manner, viz.,

List of Abbreviations

The word "bleach" is used for bleaching powder, and the term, "bleach 35 per cent." designates bleaching powder containing 35 per cent available chlorine.

The word "alcohol" designates ethyl alcohol, and the term, "alcohol 94 per cent," designates alcohol containing 94 per cent CH_3CH_2OH by volume or 188 proof.

The atomic weights used in the calculations are rounded off to the nearest half unit, viz.:

$C = 12$; $Ca = 40$; $Cl = 35.5$; $H = 1$; $O = 16$.

1000 lbs. of bleach having 35 per cent available chlorine, or its equivalent, were dissolved in the square box *A*, Fig. 1, in sufficient water to make about 25 cu.ft., and the solution was run off into still *B*, a small quantity of water being used to wash the box. Eight gallons of 94 per cent alcohol by volume were added, whereupon the still was closed and left to stand over night.

In some instances, particularly in warm weather, the reaction would start spontaneously, which could be observed by the stills warming up. In most cases, however, it was necessary to start the reaction the next morning by admitting direct steam to the stills. Care was taken to admit steam very gradually, otherwise the reaction would become very violent and the contents of the stills would

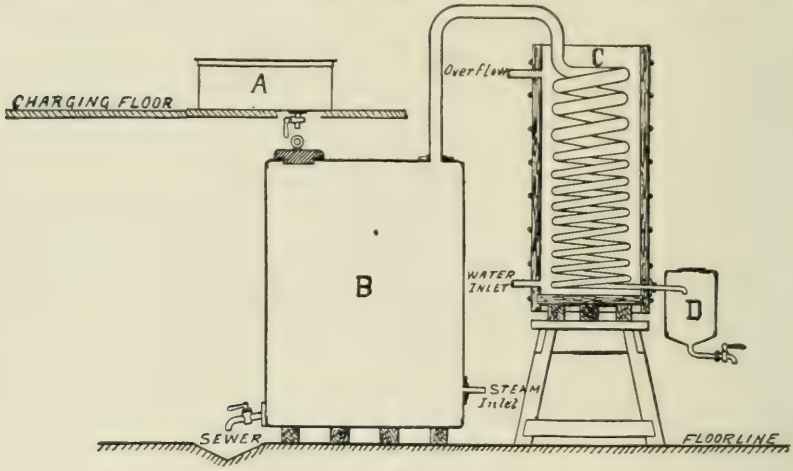


FIG. 1.

boil over. The reaction having taken place, more steam was admitted, until all of the chloroform was distilled over. The distillation was continued until the distillate did not taste of alcohol or chloroform. The distillate coming after the chloroform (5 to 10 gallons) would be added to the next charge in the stills, and would be counted as alcohol, its alcoholic content being ascertained by the hydrometer. The chloroform was separated from the distillate and purified as described later on.

When I took charge of the plant, I conducted a series of operations in the same manner as they had been conducted for years, making the following observations:

I. 934 lbs. bleach, 35.8%, enough water to make 25 cu.ft., 7.7 gallons alcohol, 94%,

were charged into still *B* at 5.30 P.M., the charge occupying less than 1 ft. in the 8-ft. still. The reaction commenced at 10 P.M., slow distillation taking place from 10 P.M. to 12.30 A.M. the following day. At 7 A.M. steam was admitted gradually, and 63 lbs. of crude chloroform of 1.40 specific gravity were distilled off. 50 c.c. of this crude chloroform, shaken with 50 c.c. water, left 44 c.c. washed chloroform of 1.48 s.g. The total product of 63 lbs. crude chloroform made 58.6 lbs. of 1.48 s.g., after washing with water. 0.4 gallon alcohol, 94 per cent, were recovered in the after distillate, and 0.7 gallon alcohol, 94 per cent, were recovered from crude chloroform, by washing with water.

II. 971 lbs. bleach, 33.0%, enough water to make 25 cu.ft., 6.9 gallons alcohol, 94%,

were charged into still *B* at 5 P.M. The reaction began at midnight, continued to 3 A.M., and 61 lbs. crude chloroform 1.46 s.g., were withdrawn from the receiver the next morning. 50 c.c. crude chloroform 1.46 s.g., shaken with 50 c.c. water made 47 c.c. washed chloroform 1.48 s.g. and the 61 lbs. crude chloroform made 58.5 lbs. washed chloroform 1.48 s.g. 0.3 gallon alcohol 94 per cent were recovered in the after distillate, and 0.4 gallon alcohol 94 per cent were obtained from the crude chloroform by washing with water.

III. 988 lbs. bleach, 33.7%, enough water to make 25 cu.ft., 7.1 gallons alcohol, 94%,

were charged into still *B* at 5 P.M. The reaction did not commence during the night. Upon admitting steam slowly the next morning, the reaction commenced suddenly and the contents of the apparatus boiled over. 53.5 lbs. crude chloroform of 1.46 s.g. were obtained. 50 c.c. of this chloroform, shaken with 50 c.c. water, made 47 c.c. washed chloroform 1.48 s.g., and the 53.5 lbs. crude chloroform made 51.3 lbs. washed chloroform of 1.48 s.g. 0.6 gallon alcohol, 94 per cent were recovered in the after distillate and 0.4 gallon alcohol, 94 per cent, were recovered from the crude chloroform by washing with water. The residue remaining in still *B* after the distillation, contained some free chlorine or its equivalent.

IV. 959 lbs. bleach, 33.2%, enough water to make 25 cu.ft., 7.0 gallons alcohol, 94%,

charged into still *B* at 6 P.M., commenced distilling voluntarily

at 10.30 P.M., and continued distilling for 2½ hours. The distillation was finished the next morning by direct steam, making 66.5 lbs. crude chloroform, 1.45 s.g., 50 c.c. of which shaken with 50 c.c. water, made 46 c.c. washed chloroform of 1.48 s.g. and the 66.5 lbs. crude chloroform made 62.6 lbs., washed chloroform, 1.48 s.g. 0.4 gallon of alcohol, 94 per cent, were recovered in the after distillate, and 0.6 gallon alcohol, 94 per cent, were recovered from the crude chloroform, by washing with water.

The mean temperature of the room at the time these experiments were made, was 16° C.

The alcohol contained in the after distillate and in the washwater from crude chloroform was measured by specific gravity. This was not quite correct on account of the aldehyde and organic chlorine compounds, but it was the best that could be done, under the circumstances.

1000 c.c. after distillate, 0.98 s.g., was distilled with 30 gms. hydrated lime, until 300 c.c. were in the receiver. 2.3 c.c. chloroform was separated. The distillate had a specific gravity of 0.930.

Each of the experiments I to IV constituted one day's work for one of the large apparatus, sketched in Fig. 1.

Conclusions and Observations from Experiments I to IV

1. Summarizing the four experiments.

3852 lbs. bleach, averaging 33.9%, equal to 3732 lbs., 35%.
Enough water to make 100 cu.ft.,
24.9 gallons alcohol, 94%,

made 231 lbs. chloroform crude washed by water, having a specific gravity of 1.48. The crude chloroform, upon washing with sulphuric acid, and redistilling, would lose 2.35 per cent of its weight and would make 225.5 lbs. pure chloroform. 28.7 gallons alcohol 94 per cent was used and alcohol equivalent to 3.8 gallons alcohol 94 per cent were recovered from the after distillate and from the wash water of the crude chloroform.

2. The manufacture of 100 lbs. pure chloroform required, on an average, 1655 lbs. bleach 35 per cent, and 11.05 gallons alcohol 94 per cent.

3. The cost price of the materials in St. Louis, January, 1883, being $1.32 per 100 lbs. bleach, containing 35 per cent chlorine, and $2.14 for one U. S. gallon of alcohol 94 per cent or 188 proof, the values

of materials contributed to the cost of 100 lbs. pure chloroform, as follows:

1655 lbs. bleach, 35%, at	$1.32	$21.85
11.05 gallons alcohol, 94%, at	2.14	23.65
Total		45.50

4. The yield of chloroform was much greater when the reaction started spontaneously, as in Exps. I, II and IV, than when it had to be started by admitting direct steam as in Exp. III. A particularly poor yield was obtained if the reaction was so violent that boiling over of the contents of the apparatus would occur.

5. In spite of the fact that only one-eighth of the space in the still was occupied by the charge, boiling over could not always be avoided.

6. In case the reaction was violent, the charge boiling over as in Exp. III, the values of the material would contribute to the cost of 100 lbs. pure chloroform, as follows:

1898 lbs. bleach, 35%, at	$1.32	$25.05
12.2 gallons alcohol, 94%, at	2.14	26.11
Total		51.16

7. In case the reaction started spontaneously, requiring 2 to 3 hours for its completion, as in Exp. I, II and IV, the average value of the materials would contribute to the cost of 100 lbs. of pure chloroform, as follows:

1584 lbs. bleach, 35%, at	$1.32	$20.91
10.71 gallons alcohol, 94%, at	2.14	22.92
Total		43.83

For the purpose of ascertaining the influence of time upon the yield of chloroform, the following experiments were made with the same apparatus.

V. 900 lbs. bleach, 35%,
Enough water to make 25 cu.ft.,
7.2 gallons alcohol, 94%.

The distillation was induced so as to begin 1½ hours after charging and was finished in 2 hours. 60.5 lbs. crude chloroform, 1.30 s.g., were obtained, which made 52.3 lbs. of washed chloroform corresponding to 51 lbs. pure chloroform.

VI. 900 lbs. bleach, 35%,
Enough water to make 25 cu.ft.,
7.2 gallons alcohol, 94%.

The distillation was induced so as to begin 2 hours after charging and was finished in 2 hours. 62 lbs. crude chloroform, 1.32 s.g., were obtained, which made 50.1 lbs. washed, corresponding to 49.0 lbs. pure chloroform.

VII. 900 lbs. bleach, 35%,
Enough water to make 25 cu.ft.,
7.2 gallons alcohol, 94%.

Distillation was induced so as to begin 4 hours after charging and was finished in 3 hours. 61.8 lbs. crude chloroform 1.41 s.g. were obtained which made 57.1 lbs. washed, corresponding to 55.8 lbs. pure chloroform.

VIII. 900 lbs. bleach, 35%,
Enough water to make 25 cu.ft.,
7.2 gallons alcohol, 94%.

Distillation was induced, so as to begin 9 hours after charging, and was finished after 5 hours. 57.8 lbs. crude chloroform 1.425 s.g. were obtained, which made 54.2 lbs. washed, corresponding to 53 lbs. pure chloroform.

Conclusions and Observations from Experiments V to VIII

8. Delaying the distillation for four or more hours after the charge is made, tends to increase the yield of chloroform.

9. In each of the Exps. V to VIII, the residue in the still did not contain any large amount of active chlorine or its equivalent.

10. In each of the experiments, an equivalent of 0.4 to 0.6 gallon of alcohol, 94 per cent, was recovered from the water distilling with the chloroform, and approximately 0.5 gallon of alcohol 94 per cent was recovered from the crude chloroform by washing with water. The same observation was made in Exps. I to IV.

11. The water coming over with the chloroform did not give any reaction for chlorine with silver nitrate but contained some organic chlorine compounds, which upon distillation with lime, made chloroform. In one experiment, 1000 c.c. distillate, mixed with 30 gms. hydrated lime, and subjected to distillation in a glass retort, yielded 3.5 gms. chloroform. The residue, which remained in the retort

after this distillation, showed a strong reaction for chlorine with silver nitrate.

12. Five liters of watery distillate from the chloroform stills, upon fractional distillation, made about 4 c.c. of an impure dichloraldehyde, boiling at 88° to 90° C.

13. The bleaching powder used for all these experiments contained an average of 15 per cent of free hydrate of lime.

It was thought that possibly an addition of hydrate of lime might have an influence on the yield of chloroform, and with this in view, the following experiments were carried out:

IX. 900 lbs. bleach, 35%,
150 lbs. hydrate of lime,
Enough water to make 25 cu.ft.,
7.2 gallons alcohol, 94%.

The distillation was induced so as to begin 3 hours after charging, and was finished in $2\frac{1}{2}$ hours. 63.25 lbs. crude chloroform 1.36 s.g. were obtained, which made 57.7 lbs. washed, corresponding to 56.4 lbs. pure chloroform.

X. 900 lbs. bleach, 35%,
170 lbs. hydrate of lime,
Enough water to make 25 cu.ft.,
7.2 gallons alcohol, 94%.

The distillation was induced so as to begin $5\frac{1}{2}$ hours after charging and was finished in $3\frac{1}{2}$ hours. 70.25 lbs. crude chloroform 1.36 s.g., were obtained, which made 62.6 lbs. washed, corresponding to 61.1 lbs. pure chloroform.

Conclusions from Experiments IX and X

14. Comparing Exp. IX with Exp. VII, it would seem that the addition of hydrate of lime has no influence on the yield of chloroform if the distillation is induced about 3 hours after charging.

15. Comparing Exp. X with Exp. VIII and IX, it appears that the addition of hydrate of lime increased the output considerably, if at the same time the reaction is delayed to about 6 hours after charging.

The following table gives the materials used for 8 large lots, and the yields obtained from same, the work being conducted on the lines given in Exp. I to IV. In each operation, the after distillate and washwater coming from the crude chloroform of the previous opera-

tion was added to the following charge. The alcohol contained therein is not given in the table and only the *fresh* alcohol is given which was used in the operations.

TABLE 1

Lot No.	Bleaching powder used.		Alcohol 94 per cent used.	Chloroform pure obtained.	100 lbs. Bleach made chloroform lbs.	For 100 lbs. chloroform were used	
	Tons of 2000 lbs.	Per cent. Cl.	U. S. gal.	lbs.		Bleach lbs.	Alcohol 94 per cent U. S. gal.
1	57	.....	905	7934	6.96	1437	11.4
2	112	.....	1768	15545	6.94	1441	11.37
3	60	.....	926	7680	6.40	1562	12.06
4	63	28	924	6678	5.3	1887	13.83
5	233	.....	3558	29358	6.3	1587	12.12
6	91	.....	1426	13104	7.2	1389	10.88
7	87	35	1382	11966	6.87	1456	11.55
8	54	$35\frac{1}{2}$	870	7992	7.4	1351	10.88
Total...	757	.....	11759	100257	.....	.....	.....
Average	.....	$33\frac{1}{3}$	.....	.....	6.622	1510	11.73

100 lbs. chloroform required the following amounts of raw material:

Bleaching powder, $33\frac{1}{3}\%$..... 1510 lbs.
Alcohol, 100%..... 72–73 lbs.

equal to 11.73 U. S. gallons, 94 per cent.

It is generally assumed that the formation of chloroform takes place according to the following reaction:

$$2[CH_3CH_2OH+4CaClOCl]=2CCl_3COH+3Ca(OH)_2+5CaCl_2+2H_2O$$

$$=2CCl_3H+(HCOO)_2Ca+2Ca(OH)_2+5CaCl_2+2H_2O.$$

If this equation is correct, then for 100 lbs. chloroform, the following quantities of raw materials should have been used:

Bleach, $33\frac{1}{3}\%$..... 713.00 lbs.
Alcohol, 100%..... 38.50 lbs.

In place of this, more than twice as much bleach and almost twice as much alcohol were used in the manufacture of a lot of approximately 100,000 lbs. of chloroform.

Since the waste liquor from the stills contained only traces, but not any appreciable amounts of active chlorine, the waste of material could be caused only by the oxidation of the formate of calcium to carbonate of calcium, or by the oxidation of alcohol, or by both.

If all of the formate of calcium coming from the chloroform reaction had been oxidized, then 178 lbs. bleach, 33⅓ per cent, would have been sufficient to do this work. By the formula

$$Ca(COOH)_2 + 2CaClOCl + Ca(OH)_2 = 2CaCO_3 + 2CaCl_2 + 2H_2O,$$

and the hydrated lime necessary for this reaction would also be furnished by the chloroform reaction.

But frequent analyses of the waste liquor have revealed the fact, that only about ⅓ of the formate of calcium formed in the reaction was oxidized, while ⅔ would run off with the waste liquor. This would leave more than 619 lbs. bleach, 33⅓ per cent, not accounted for, which, together with 33.5 lbs. alcohol, 100 per cent, were lost in the reaction.

This bleaching powder must have reacted with the alcohol and the oxidation of part of the alcohol must have progressed to the formation of carbonic acid and water, since only in this way can the large quantities of carbonate of lime be accounted for, which were found in the waste liquors. A small proportion was consumed in the formation of dichloraldehyde, which was found in the water distilling with and after the chloroform, and another part formed, with alcohol, aldehyde and other products of decomposition, which had to be eliminated from the crude chloroform by washing with concentrated sulphuric acid, forming a black and often muddy mixture.

The presence of organic chlorine compounds was also proven by the voluminous escape of pungent gases, which often drove the laborers from the apparatus room, making the work very disagreeable and difficult to control.

Exps. I to IV, and also V to X, were made with fresh alcohol, no alcohol coming from a previous operation being used.

In continuous operation the weak alcohol distilling off with the chloroform and the washwater from the crude chloroform of a previous operation was used in the following operation, and it was observed that in any first operation the yield of chloroform would be smaller than in subsequent operations in which the after distillate and the

washwater from crude chloroform containing alcohol and organic chlorine compounds was used in place of part of the alcohol.

If in the first operation the yield of chloroform was 5.5 per cent from the weight of bleach, 35 per cent, used, then in the subsequent operations, in which the after distillate and washwater from the previous operation were used in place of part of the alcohol the charge would yield as much as 6.5 or even 7 lbs. chloroform from every 100 lbs. bleach, 35 per cent, used in the operation. This would seem to indicate that the alcohol is transformed into chloroform by steps or by a number of consecutive reactions. This being the case it seemed not to be sufficient to draw conclusions from a single experiment but a series of experiments had to be made, the after distillate and washwater from the previous experiment always being used for the following experiments of the series.

It was also observed that the proportion of the yield from a first operation to the yield in a subsequent operation was fairly constant and for this reason Exps. I to X have comparative value.

The purification of the crude chloroform was accomplished by repeated washing with sulphuric acid, 66° B., to eliminate organic substances, and subsequent washing with a diluted solution of carbonate of sodium, followed by washing with water and final distillation in a rectifying still. The washing was done by hand. The finished chloroform was dried by shaking with dry chloride of calcium, which was absolutely neutral, whereupon it was filtered and mixed with 1 per cent absolute alcohol to improve its keeping qualities. It is essential that alcohol, used for this purpose be almost free from water, and no alcohol having more than 0.2 per cent water would be taken for this purpose.

The labor connected with the operation of six chloroform stills was as follows:

1 foreman who operated six stills,
2 laborers for charging stills,
1 laborer for washing chloroform,
$\frac{1}{3}$ the time of one operator for the rectifying still.

Work was done in day time only and 10 hours constituted a day's work.

Approximately $\frac{3}{4}$ ton steam of 80 lbs. pressure was used for one operation in each still and six apparatus were operated once a day and each apparatus would take about 900 lbs. bleaching powder, making approximately 60 lbs. of chloroform.

The chloroform, when finished by rectification and dried by chloride of calcium, would be tested rigorously by two tests.

1st. One ounce chloroform shaken with $\frac{1}{2}$ ounce distilled water, upon addition of a few drops of a 10 per cent solution nitrate silver, was not to give the faintest reaction for chlorine.

2d. One ounce of chloroform, shaken for two minutes with $\frac{1}{4}$ ounce of colorless and pure sulphuric acid 66° B., was not to show even the faintest discoloration, after standing ten minutes.

The process as described, was at that time in use in many places for the production of chloroform. The results were not particularly bad, compared with those obtained by others. Inquiries from friends in the United States and in Europe, who were in a position to know proved that other manufacturers obtained similar results. Besides, the fact that a number of manufacturers were eager to obtain possession of an improved process, when it was found, gave cause to believe that they themselves, were working with inferior results.

The great losses in material seemed to me to justify the following investigation with reasonable prospect of success. There were two ways of going at it. One was to experiment with the large apparatus by changing conditions as far as the construction of the apparatus would permit. This method could be carried out in the regular course of work and the cost of experimenting would apparently be absorbed by current manufacturing expenses, but this course seemed to involve a deception of my employer and it seemed tedious and incomplete, since the arrangement of a given apparatus would not allow any fundamental changes, which might be necessary before results could be obtained.

The second way was to translate the process into small proportions and to carry the investigation out on a laboratory scale and to use the results of this investigation for improving the process on a larger scale.

There was a special consideration for me, which prompted me to choose the second method. I had entered the plant 3 years before I decided upon this investigation. Coming fresh from a German University where I had graduated after $3\frac{1}{2}$ years' study and where I had held a position as assistant in charge of analytical work for 5 years following my graduation, I had no experience in the line of work, which was entrusted to me, except, what was given to me in the way of meager information by my employer.

The business in which I was employed ran entirely satisfactorily,

with the processes in use. The selling price of chloroform had been as high as $1.30 but had dropped to 90 cents while its cost with the old process was about 50 cents per lb.

My employer had picked up this process in a German factory, where it had been operated for a long time, and he thought he was operating the most practical process known to successful manufacturers. In this assumption he did not seem to be mistaken, since inquiries subsequently made, established the fact that other German manufacturers operated at a similar disadvantage.

There was little inclination to spend money for experiments and I did not think it advisable to make radical changes with the larger apparatus in the regular routine of business, where expenses for experimental work were absorbed by current manufacturing expenses, upon my own responsibility. This was particularly the case since experiments were to be made in a direction in which German manufacturers were known to have experimented, but had failed.

By day, my time was taken up by routine work, and if I wanted to make the research, I had to do it at night. A rather primitive laboratory, consisting of a room in the basement with an experimenting table was at my disposal and I had gas for lighting and heating. Water was to be carried in with buckets. Whatever apparatus I needed, I secured at my own expense, since it was my intention to remain the owner of the improved process, if I should find it. Bleaching powder, alcohol, and reagents I used from the stock of the company but I kept account of whatever I used for the purpose of settling for it as soon as I could offer an improved process to my employer.

The work was designed in the following manner:

1st. The existing manufacturing process was translated into laboratory scale by carrying out the operation in glass apparatus, but taking the same proportions of materials as were used in the large stills and working them in apparatus of proportionate dimensions. The results obtained on a small scale were compared with the results in the large plant, and a constant was obtained which allowed me to compare the results on a small scale made with an apparatus of definite design, with results which could be expected in actual practice with larger stills.

2d. With the apparatus arranged as described in the first paragraph, the proportions of materials and conditions of operations

were varied, care being taken to change the apparatus itself as little as possible, since any change in the small apparatus would imply a corresponding change in the large plant. In this manner, the expenses connected with such changes were kept down to the least possible amount.

3d. The process arrived at by the research was translated into practice by changing the large apparatus by the results of the experiments, and using the proportions of materials and temperatures found to be most profitable in the research work.

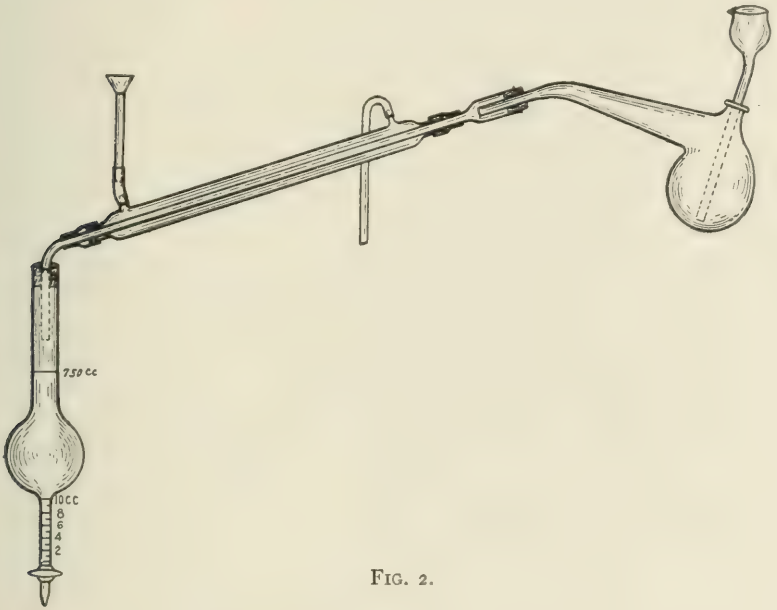


FIG. 2.

The translation of the existing manufacturing process to a laboratory scale was done by arranging the glass apparatus, Fig. 2, and by executing with this apparatus the experiments, series *A* and *B* for the purpose of determining the relation between the results obtained by operations on a factory and laboratory scale.

EXPERIMENTS SERIES A, comprising two experiments, and representing two days' work in the plant, were made for the purpose of comparing factory results with laboratory experiments. Apparatus, Fig. 2, used, with 1500 c.c. retort, measured inclusive of neck, and having a straight neck.

During the distillation, 2 c.c. water were introduced into the retort by

way of a long stem funnel for every 1 c.c. water distilled, in order to imitate the accumulation of condensed water from direct steam in the large stills.

1. Materials used: 100 grams bleach, 35 per cent; enough water to make 175 c.c.; 6.7 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 5.7 grams washed chloroform, s.g. 1.48.

2. Materials used: 100 grams bleach, 35 per cent; enough water to make 175 c.c.; 6.7 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 5.5 grams washed chloroform, s.g. 1.48.

16. *Conclusions.* Comparing the results of laboratory Exps. 1 and 2 of Series A, with factory Exps. V to VIII, it appears that experiments on a large scale yield somewhat more chloroform than laboratory experiments.

17. The results of laboratory experiments carried out in the manner described, are of such character that conclusions can be drawn with reference to the working of corresponding experiments made on a large scale.

This is confirmed by later observation, comparing experiments made on a large and small scale, and the difference would seem to range from 5 to 7 per cent of the product.

Compare Series B with the working of large lot 7, page 142.

EXPERIMENTS SERIES B, comprising ten experiments and representing ten days' work in the large plant, were made for the purpose of determining the yield in subsequent operations, if the after distillate and washwater of crude chloroform from the previous experiment were used for the following operation, in a manner which imitated continuous work in actual practice.

The proportion of alcohol to bleach was regulated to be the same as in the old process, lot No. 7, page 142, in which lot 87 tons = 78,926 kg. bleach, 35 per cent, with 1382 U. S. gallons = 5230 liters alcohol, 94 per cent, made 11,966 lbs. = 5428 kg. pure chloroform. For this reason this series of experiments compared with lot 7, page 142, gives a good idea of the working of the process on a large and laboratory scale.

Apparatus, Fig. 2, used, with 1500-c.c. retort, having a straight neck.

During the distillation, 2 c.c. water were introduced into the retort by way of the long stem funnel for every 1 c.c. water distilled, in order to imitate the accumulation of condensed water from direct steam in the large stills.

1. Materials used: 100 grams bleach, 35 per cent; enough water to make 175 c.c.; 6.7 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 5.5 grams chloroform washed, 1.48 s.g., 50 c.c. diluted alcohol (distillate A).

2. Materials used: 100 grams bleach, 35 per cent; 50 c.c. distillate A; enough water to make 175 c.c.; 6.7 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 6.4 grams washed chloroform, 1.48 s.g., 50 c.c. diluted alcohol (distillate B).

3. Materials used: 100 grams bleach, 35 per cent; 50 c.c. distillate B; enough water to make 175 c.c.; 6.7 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 6.9 grams washed chloroform, 1.48 s.g., 50 c.c. diluted alcohol (distillate C).

The following numbers of this series were made in the same manner. In each number, bleach and water were well mixed, filled up to the required volume, and put cold into the retort of the apparatus. After distillate, washwater of crude chloroform, and alcohol were added when cold, the reaction was induced by gently heating.

The results of experiments, Series B, are entered in the following table.

TABLE II

Series B. No.	Materials used.				Products.	
	Bleach 35 per cent. Grams.	Water to make solution. c.c.	Diluted alcohol from previous operation. c.c.	Alcohol 94 per cent. c.c.	Washed chloroform 1.48 s.g. Grams.	Diluted alcohol. c.c.
1	100	175	....	6.7	5.5	50
2	100	125	50	6.7	6.4	50
3	100	125	50	6.7	6.9	50
4	100	125	50	6.7	6.8	50
5	100	125	50	6.7	7.0	50
6	100	125	50	6.7	6.9	50
7	100	125	50	6.7	6.8	50
8	100	125	50	6.7	7.1	50
9	100	125	50	6.7	6.9	50
10	100	125	50	6.7	6.8	50
Totals . .	1000	....	....	67.0	67.1	.....

The 67.1 grams washed chloroform 1.48 s.g.,* corresponded to 65.5 grams of pure chloroform 1.5 s.g., and the amount of chloroform obtained was approximately 1 gram of chloroform for every cubic centimeter alcohol, 94 per cent, used in the experiment.

Comparing the results of experiments, Series B, with the results obtained in lot 7, page 142, in which 78,926 kg. bleach, 35 per cent, and 5230 liters alcohol, 94 per cent, made 5428 kg. pure chloroform (which is equivalent to 7.042 grams washed chloroform, 1.48 s.g., from 6.626 c.c. alcohol, 94 per cent, and 100 grams bleach, 35 per cent),

* 100 grams washed chloroform, 1.48 s.g., would make 97.65 grams pure chloroform, after purifying with sulphuric acid, 66°, and redistilling.

it is seen that the difference between results obtained in the laboratory and the results in the large plant, were about 5 per cent in favor of practical work for bleach, while for alcohol, the consumption was not more than in actual work.

18. *Conclusion.* The results obtained in the large apparatus in the plant and those obtained in the laboratory, with apparatus, Fig. 2, could be compared, the difference being about 5 per cent in favor of work on a large scale for bleach.

For this reason, reliable conclusions could be drawn from laboratory experiments made with apparatus, Fig. 2, upon the working of the large apparatus in the plant.

In the following pages, a line of experiments is recorded, which led systematically to a superior process and by the results of these experiments, the plant was reconstructed, doing, after a very simple change, twice the work which it did before and making, at the same time, a saving of almost one-third of all the bleaching powder used in the process.

EXPERIMENTS SERIES C, comprising nine experiments and representing nine days' work in the plant, were made for the purpose of ascertaining whether dilution of the charge with water would have any influence upon the yield of chloroform.

Apparatus, Fig. 2, was used with 1500-c.c. retort. The experiments were made in the same manner as the experiments of series B, with the only exception that 1000 c.c. water were taken in place of 175 less volume of 100 grams bleach dissolved in same, and that 300 c.c. were distilled off instead of 50 c.c.

TABLE III

Series C.	Materials used.				Products.	
	Bleach 35 per cent.	Water.	After distillate from previous portion	Alcohol 94 per cent.	Washed chloroform.	After distillate.
No.	Grams.	c.c.	c.c.	c.c.	Grams.	c.c
1	100	1000	....	6.7	none	300
2	100	700	300	6.7	trace	300
3	100	700	300	6.7	0.3	300
4	100	700	300	6.7	0.5	300
5	100	700	300	6.7	3.0	300
6	100	700	300	6.7	2.4	300
7	100	700	300	6.7	3.3	300
8	100	700	300	6.7	3.5	300
9	100	700	300	6.7	3.0	300

19. *Conclusions* from Series C, compared with Series B. Dilution with water would diminish the yield of chloroform.

Experiments Series D, comprising twelve experiments and representing twelve days' work in the plant, were made for the purpose of ascertaining whether dilution with water, combined with increase of alcohol, would have any influence upon the yield of chloroform.

Apparatus and operation were the same as in Series C.

TABLE IV

Series D.	Materials used.				Products.	
No.	Bleach 35 per cent. Grams.	Water. c.c.	After distillate from previous portion. c.c.	Alcohol 94 per cent. c.c.	Washed chloroform. Grams.	After distillate. cc.
1	100	1000	....	20	1.2	300
2	100	700	300	20	3.6	300
3	100	700	300	20	5.4	300
4	100	700	300	20	7.5	300
5	100	700	300	20	6.7	300
6	100	700	300	20	9.0	300
7	100	700	300	20	9.7	300
8	100	700	300	20	10.5	300
9	100	700	300	20	10.3	300
10	100	700	300	20	10.5	300
11	100	700	300	20	9.8	300
12	100	700	300	20	10.0	300

Remarks. The last after distillate had a specific gravity of 0.970. The crude chloroform from Exps. 8 to 12 combined was washed with 50 c.c. concentrated sulphuric acid, whereby its weight was reduced from 49 grams to 46 grams, the purified chloroform having a specific grrvity of 1.5.

The sulphuric acid was very little discolored, much less so than by crude chloroform obtained in lot 7, page 142, thus showing greater purity of the crude product.

20. *Conclusions from Series D.* Comparing Series C and D, it appears that the concentration of alcohol is of material interest upon the yield of chloroform. Taking from Table, Series L, that 20 c.c. alcohol make more than 16 grams chloroform, it follows from Table, Series D, that in the eighth operation, in which the concentration of alcohol was nearly 10 per cent, the maximum yield was reached. Greater concentration did not give any further increase in the output of chloroform.

21. Comparison of Series D with Series B, shows an increase of the alcohol proportion in presence of more water, increases the yield of chloroform obtained by the old process.

22. The chloroform obtained is purer than by the old process.

EXPERIMENTS SERIES E, comprising four experiments, were made to determine whether a large excess of alcohol will increase the yield of chloroform.

Apparatus Fig. 2 used, with 1500-c.c. retort. In each of the experiments, 700 c.c. alcohol and water were distilled off, after the chloroform and the alcoholic distillate from each operation, was used for the following operation, in place of alcohol, no fresh alcohol being added.

1. Materials used: 100 grams bleach, 35 per cent; enough water to make 500 c.c.; 500 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 6.7 grams washed chloroform, s.g. 1.48, 700 c.c. diluted alcohol (distillate A).

2. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 700 c.c. distillate A; mixed at 20° C. and distilled. Products obtained: 9.0 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol, (distillate B).

3. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 700 c.c. distillate B; mixed at 20° C. and distilled. Products obtained: 11.5 grams washed chloroform s.g. 1.48; 700 c.c. diluted alcohol (distillate C).

4. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 700 c.c. distillate C; mixed at 20° C. and distilled. Products obtained: 9.1 grams chloroform, washed, 1.48 s.g.; 700 c.c. diluted alcohol (distillate D).

TABLE V.—COMPARISON OF EXPERIMENTS, SERIES C, D AND E

Experiment. No.	Bleach 35 per cent used. Grams.	Chloroform washed, s.g. 1.48, obtained in		
		Series C. Grams.	Series D. Grams.	Series E. Grams.
1	100	none	1.2	6.7
2	100	trace	3.6	9.0
3	100	0.3	5.4	11.5
4	100	0.5	7.5	9.1
5	100	3.0	6.7	
6	100	2.4	9.0	
7	100	3.3	9.7	
8	100	3.5	10.5	

EXPERIMENTS SERIES E^a, comprising four experiments, and representing four days' work in the plant, were made for the same purpose as E. Only 200 c.c. alcohol added in the first operation, in place of 500 c.c.

Apparatus Fig. 2 used, with 1500-c.c. retort.

1. Materials used: 100 grams bleach, 35 per cent; enough water to make 800 c.c.; 200 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 6.75 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol, (distillate A).

2. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 700 c.c. distillate A; mixed at 20° C. and distilled. Products obtained: 8.4 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol (distillate B).

3. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 700 c.c. distillate B; mixed at 20° C. and distilled. Products obtained: 10.5 grams washed chloroform s.g. 1.48; 700 c.c. diluted alcohol (distillate C).

4. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 700 c.c. distillate C; mixed at 20° C. and distilled. Products obtained: 10.0 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol (distillate D).

Experiments Series E', comprising four experiments and representing four days' work in the plant, were made for the same purpose as E. Only 100 c.c. alcohol was added in the first operation in place of 500 c.c.

Apparatus Fig. 2 used, with 1500-c.c. retort. Operations the same as E, only 500 c.c. diluted alcohol distilled off, in place of 700 c.c.

1. Materials used: 100 grams bleach, 35 per cent; enough water to make 900 c.c.; 100 c.c. alcohol; mixed at 20° C. and distilled. Products obtained: 6.7 grams chloroform washed, 1.48 s.g.; 500 c.c. diluted alcohol (distillate A).

2. Materials used: 100 grams bleach, 35 per cent; enough water to make 500 c.c.; 500 c.c. distillate A; mixed at 20° C. and distilled. Products obtained: 8.2 grams washed chloroform, s.g. 1.48; 500 c.c. diluted alcohol (distillate B).

3. Materials used: 100 grams bleach, 35 per cent; enough water to make 500 c.c.; 500 c.c. distillate B; mixed at 20° C. and distilled. Products obtained: 7.5 grams washed chloroform, s.g. 1.48; 500 c.c. diluted alcohol (distillate C).

4. Materials used: 100 grams bleach, 35 per cent; enough water to make 500 c.c.; 500 c.c. distillate C; mixed at 20° C. and distilled. Products obtained: 6.7 grams washed chloroform, s.g. 1.48; 500 c.c. diluted alcohol (distillate D).

23. *Conclusions from Series E, E' and E''.* The presence of large excess of alcohol increases the yield of chloroform from the same amount of bleach, 35 per cent, but the increase is not in proportion to the amount of alcohol present. Series E'' indicates that 100 c.c. alcohol, 94 per cent, for 100 grams bleach and enough water to make 1000 c.c., gives the largest yield in chloroform, with the least amount of alcohol. The yield was diminished in the third and fourth operations

of Series E^b, when about 15 c.c. of the 100 c.c. alcohol was consumed for the production of 6.7 and 8.2 grams = 14.9 grams chloroform obtained in operations 1 and 2.

TABLE VI.—COMPARING RESULTS OF SERIES E, E^a AND E^b

Operations. No.	Series E. 100 grams bleach, 35 per cent, 500 c.c. alcohol, 94 per cent, water to make 1000 c.c. Temp. of mixing, 20° C. Made washed chloroform. Grams.	Series E^a 100 grams bleach 35 per cent, 200 c.c. alcohol, 94 per cent, water to make 1000 c.c. Temp. of mixing, 20° C. Made washed chloroform. Grams.	Series E^b 100 grams bleach, 35 per cent, 100 c.c. alcohol, 94 per cent, water to make 1000 c.c. Temp. of mixing, 20° C. Made washed chloroform. Grams.
1	6.7	6.75	6.7
2	9.0	8.4	8.2
3	11.5	10.5	7.5
4	9.1	10.9	6.7

24. Increase of the alcohol proportion to 200 c.c. and even to 500 c.c. for 100 grams bleach, 35 per cent, and enough water to make 1000 c.c., does not increase the yield of chloroform.

EXPERIMENTS SERIES F, comprising six experiments and representing six days' work in the plant, were made to determine whether that part of ethyl alcohol which is destroyed in the reaction, can be substituted by methyl alcohol.

Apparatus Fig. 2 was used, with 1500-c.c. retort.

The experiments were made in the same manner as the experiments of Series E, only the larger part of the ethyl alcohol was substituted by methyl alcohol.

1. Materials used: 100 grams bleach, 35 per cent; enough water to make 500 c.c.; 20 c.c. ethyl alcohol, 94 per cent; 500 c.c. methyl alcohol 90 per cent, free of acetone; mixed at 20° C. and distilled. Products obtained: 1.2 grams chloroform washed, 1.48 s.g.; 700 c.c. diluted mixed alcohols (distillate A).

2. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 20 c.c. ethyl alcohol, 94 per cent; 700 c.c. distillate A; mixed at 20° C. and distilled. Products obtained: 3.7 grams washed chloroform, s.g. 1.48; 700 c.c. diluted mixed alcohols (distillate B).

3. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 20 c.c. ethyl alcohol, 94 per cent; 700 c.c. distillate B; mixed at 20° C. and distilled. Products obtained: 5.2 grams washed chloroform, 1.48 s.g.; 700 c.c. diluted mixed alcohols (distillate C).

4. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 20 c.c. ethyl alcohol, 94 per cent; 700 c.c. distillate C.

mixed at 20° C. and distilled. Products obtained: 7.2 grams chloroform washed, s.g., 1.48; 700 c.c. diluted mixed alcohols (distillate D).

5. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 20 c.c. ethyl alcohol, 94 per cent; 700 c.c. distillate D; mixed at 20° C. and distilled. Products obtained: 7.6 grams chloroform washed, s.g., 1.48; 700 c.c. diluted mixed alcohols (distillate E).

6. Materials used: 100 grams bleach, 35 per cent; enough water to make 300 c.c.; 20 c.c. ethyl alcohol, 94 per cent; 700 c.c. distillate E; mixed at 20° C. and distilled. Products obtained: 7.8 grams chloroform washed, s.g. 1.48; 700 c.c. diluted mixed alcohols (distillate F).

TABLE VII.—COMPARISON OF EXPERIMENTS SERIES D AND F

Number of experiment.	Bleach 35 per cent used.	Chloroform washed, s.g. 1.48, obtained in	
No.	Grams.	Series D.	Series F.
1	100	1.2	1.2
2	100	3.6	3.7
3	100	5.4	5.2
4	100	7.5	7.2
5	100	6.7	7.6
6	100	9.0	7.8

25. *Conclusions from Series F.* Comparing experiments Series D and F, it is proven that the presence of large amounts of methyl alcohol (free of acetone) in presence of a small amount of ethyl alcohol, does not increase the yield of chloroform from bleach.

EXPERIMENTS SERIES G. comprising nine experiments, were made for the purpose of studying the decomposition of chloral hydrate with water and hydrated lime.

It is supposed that the decomposition runs by the following equation:

$$2CCl_3CH(OH)_2 + Ca(OH)_2 = 2HCCl_3 + (HCO_2)_2Ca + 2H_2O.$$

The chloral hydrate crystals and hydrated lime used for the following experiments were free from hydrochloric acid. Apparatus, Fig. 2, was used with a 1500 c.c. retort. In each of the following experiments 30 grams chloral hydrate were used which theoretically would require 6.71 grams $Ca(OH)_2$ for decomposition and would make 21.6 grams of chloroform. Hydrated lime was taken in excess of theory. This was done because the reaction was studied as part

of the chloroform formation occurring in the action of bleaching powder upon alcohol, in which case hydrated lime was always present in excess. To secure quick mixing the chloral hydrate was used in form of solution having 30 grams chloral hydrate to 100 c.c. The distillation was carried out as in the former experiments.

1. Materials used: 15 grams $Ca(OH)_2$; 1000 c.c. water; 30 grams chloral hydrate dissolved in 70 c.c. water, mixed at 18° C. and distilled. Products obtained: 15 grams chloroform and 40 c.c. water.

The 40 c.c. water were separated from the chloroform and returned to the retort together with additional 15 grams hydrated lime, and the distillation was repeated but no additional chloroform was obtained. The contents of the retort were analyzed for chlorine by filling up to 1500 c.c., filtering off 50 c.c. solution, neutralizing these 50 c.c. exactly with nitric acid and titrating with standard silver solution, using potassium chromate as indicator. So much chlorine was found as was contained in 1.86 grams of chloroform.

The 1450 c.c. of material not used for this analysis was acidulated with nitric acid to dissolve all of the hydrated lime, and in an aliquot part of the solution chlorine was determined by the gravimetric method of precipitating with nitrate silver and weighing as silver chloride. The result was the same as the value found by titration.

In order to find out whether the proportion of hydrated lime would influence the yield of chloroform, the same experiment was repeated with the same quantities of materials and under the same conditions with the only exception that the quantity of hydrated lime was varied. In all instances the materials were mixed at ordinary temperature and slowly heated until 50 c.c. had been distilled over. The chloroform was then separated from the water, the latter being returned to the retort. In a second distillation, in no case was any additional chloroform obtained. The results were as follows, viz.:

2. Materials used: 25 grams hydrated lime; 1000 c.c. water; 30 grams chloral hydrate, dissolved in 70 c.c. water; mixed at 18° C. and distilled. Products obtained: 15.1 grams chloroform.

The contents of the retort were analyzed for chlorine in the same manner as described in Series G1, and chlorine was found equivalent to 1.53 grams chloroform.

The experiments with these proportions and the same temperature were repeated a second and a third time, with the following results:

2^a. 15.75 grams chloroform were obtained and nitrate of silver would precipitate from the neutralized contents of the retort an amount of chlorine equivalent to 1.80 grams chloroform.

2^b. 15.7 grams chloroform were obtained and nitrate of silver would precipitate from the neutralized contents of the retort an amount of chlorine equivalent to 1.78 grams chloroform.

Average of Series G2. 2^a. and 2^b. 15.5 grams chloroform and chloride of calcium, equivalent to 1.7 grams chloroform were obtained, out of a possible total of 21.6 grams. The difference of 4.4 grams of chloroform, or its equivalent, was decomposed into other organic chlorine compounds.

3. Materials used: 50 grams hydrated lime; 1000 c.c. water; 30 grams chloral hydrate dissolved in 70 c.c. water; mixed at 18° C. and distilled. Products obtained: 15.3 grams chloroform, and silver nitrate would precipitate in the acidulated contents of the retort an amount of chlorine equivalent to 1.46 grams chloroform.

26. *Conclusion from Series G1; 2; 2^a; 2^b; and 3.* A large excess of hydrated lime has no influence upon the yield of chloroform from chloral hydrate. In using 15, 25, and 50 grams of lime, respectively, upon 30 grams of chloral hydrate 15, 15.5 and 15.3 grams chloroform were obtained in the respective experiments, and chlorine in inorganic compounds equivalent to 1.86, 1.70 and 1.46 grams chloroform could be precipitated from the residual material in the retort by silver nitrate. The respective values of chloroform added, would give 16.86, 17.2, and 16.76 grams accounted for, as against 21.6 grams required by theory. This would tend to prove, that under the conditions of the experiments a large proportion of the chloral hydrate is decomposed into organic chlorine compounds, not chloroform, which would account for part of the loss in the manufacture of chloroform from bleach and alcohol.

This series of experiments was continued by varying the temperature at which the materials were mixed and reacted upon. All the following experiments were executed in the same manner as Nos. 1, 2, and 3, with the only exception of the temperatures observed. In each case, the first 50 c.c. water distilling over with the chloroform were returned to the retort and upon repeated distillation, no additional chloroform was obtained.

Apparatus, Fig. 2, used with 1500 c.c. retort (long stem funnel in retort).

4. Materials used: 25 grams hydrated lime; 1000 c.c. water; heated to 80° C.; 30 grams chloral hydrate; 70 c.c. water; 18° C. warm poured by a long stem funnel into the milk of lime contained in the retort, and distilled. Products obtained: 16.5 grams chloroform and silver nitrate would pre-

cipitate from the neutralized contents of the retort an amount of chlorine equivalent to 1.52 grams of chloroform.

5. Materials used: 25 grams hydrate of lime; 1000 c.c. water; heated to boiling-point; 30 grams chloral hydrate; 70 c.c. water; 18° C. warm poured by a long stem funnel into the boiling milk of lime contained in the retort and distilled. Products obtained: 18.4 grams chloroform and silver nitrate would precipitate from the neutralized contents of the retort an amount of chlorine equivalent to 1.11 grams of chloroform.

5^a. Exp. No. 5 was repeated in exactly the same manner.

18.4 grams chloroform were obtained and silver nitrate would precipitate from the neutralized contents of the retort an amount of chlorine equivalent to 1.39 grams chloroform.

As an average of 5 and 5^a, 18.4 grams chloroform and chloride of calcium equivalent to 1.25 grams chloroform were obtained, out of a possible 21.6 grams.

The difference of 1.95 grams of chloroform or its equivalent was decomposed into other organic chlorine compounds.

27. *Conclusions from Series G2, 2^a, 2^b, 4, 5, and 5^a.* The temperature at which the materials are brought together is of marked influence upon the yield of chloroform from chloral hydrate and hydrated lime. The yield is greatest if the materials are mixed at the boiling-point of their solutions.

28. The yield was, in three experiments, 15.1, 15.75, and 15.7 grams out of a possible 21.6 grams of chloroform, if the ingredients were mixed at ordinary temperature.

29. The yield was in one experiment, 16.5 grams, out of a possible 21.6 grams of chloroform if the ingredients were mixed at 80° C.

30. The yield was in two experiments, 18.4 and 18.4 grams, out of a possible 21.6 grams of chloroform, if the ingredients were mixed at the boiling-point of their solutions.

31. The destruction of organic chlorine compounds by action of hydrated lime was equivalent to the complete destruction of chloroform ranging from 1.11 grams to 1.86 grams, out of a possible 21.6 grams.

32. In all instances, some organic chlorine compounds, not chloroform, were produced, the amounts of which ranged from an equivalent of 1.95 grams to 4.4. grams chloroform, out of a possible total of 21.6 grams.

33. More organic chlorine compounds, not chloroform, were formed if the solutions were mixed cold than if they were mixed hot.

34. More chloroform was destroyed if the solutions were mixed cold than if they were mixed hot.

EXPERIMENTS SERIES H, comprising four experiments and representing four days' work in the plant, were made to ascertain the influence of calcium hydrate upon the formation of chloroform.

The experiments Series E^a, were repeated with the variation that 20 grams hydrated lime were added to the charge in the retort in each experiment.

The yield in washed chloroform, 1.48 s.g., in four consecutive experiments was 6.5, 8.6, 10.3, and 11.1 grams, respectively.

EXPERIMENTS SERIES H^a, comprising four experiments and representing four days' work in the plant, were made to ascertain the influence of calcium hydrate upon the formation of chloroform.

The experiments Series E^a, were repeated with the variation that the 15.5 per cent of free calcium hydrate, which was present in the bleach, was neutralized by 10 per cent hydrochloric acid before addition of the alcohol. Temperature in mixing 20° C.

The yield in washed chloroform, 1.48 s.g., in four consecutive experiments, was 6.8, 9.1, 9.8, and 10.5 grams, respectively.

EXPERIMENTS SERIES H^b, comprising four experiments and representing four days' work in the plant, were made to ascertain the influence of calcium hydrate upon the formation of chloroform.

The experiments Series E^a, were repeated, with the variation that the 15.5 per cent of free calcium hydroxide, which was present in the bleach, was neutralized by 10 per cent hydrochloric acid before addition of the alcohol. Temperature in mixing 20° C.

Subsequently, the temperature was slowly raised until the chloroform reaction was induced (about 80° C.), which could be observed by the mixture becoming milky, from separated hydrated lime. The contents of the retort were then neutralized again by adding 10 per cent hydrochloric acid. The amount of hydrochloric acid used for the second neutralization corresponded to 6.5 grams $Ca(OH)_2$ as an average of four experiments. 2.4 grams $Ca(OH)_2$ were used up for the decomposition of organic chlorine compounds.

Finally, the chloroform and alcohol were distilled off in the same manner as described in the experiments Series E.

The yield in washed chloroform, s.g. 1.48, in four consecutive experiments was, 6.7, 8.8, 9.7, and 10.8 grams, respectively.

TABLE VIII.—COMPARING RESULTS OF EXPERIMENTS, SERIES H, H^a, H^b, WITH E^a

Operation. No.	Series E*a*. 100 grams bleach, 35 per cent; 200 c.c. alcohol, 94 per cent; water to make 1000 c.c. Temperature 20° C. made chloroform grams.	Series H. 100 grams bleach, 35 per cent; 200 c.c. alcohol, 94 per cent; water to make 1000 c.c.; 20 grams $Ca(OH)_2$. Temperature 20° C. made chloroform grams.	Series H*a*. 100 grams bleach, 35 per cent; 300 c.c. H_2O neutralized with HCl 10 per cent; 200 c.c. alcohol, 94 per cent; water to make 1000 c.c. Temperature 20° C. made chloroform grams.	Series H*b*. 100 grams bleach, 35 per cent; 300 c.c. H_2O neutralized with HCl 10 per cent; 200 c.c. alcohol, 94 per cent; water to make 1000 c.c. Temp. 20° C. heated and neutralized again with 10 per cent HCl made chloroform grams.
1	6.75	6.5	6.8	6.7
2	8.4	8.6	9.1	8.8
3	10.5	10.3	9.8	9.7
4	10.9	11.1	10.5	10.8

35. *Conclusion from Series E^a, H, H^a and H^b.* Larger or smaller quantities of hydrated lime present during the reaction have no marked influence upon the formation of chloroform from bleach and alcohol, but part of the calcium hydrate generated by the chloroform reaction combines *in statu nascendi* with chlorine coming from organic chlorine compounds. As an average from Series H^b, 8.9 grams $Ca(OH)_2$ were formed by the chloroform reaction, 2.4 grams of which combined again with chlorine taken from organic compounds, to make calcium chloride.

Experiments Series I. comprising three experiments and representing three days' work in the plant, were made for the purpose of determining the temperature at which the chloroform reaction takes place, and to ascertain the amount of $Ca(OH)_2$ formed in the chloroform reaction. Apparatus, Fig. 2, was used, with 2500-c.c. retort.

A filtered solution of bleach in water, containing 35 grams of active chlorine and 2.3 grams $Ca(OH)_2$ in one liter, was used in the following experiments. One liter of this solution would correspond to 100 grams bleach 35 per cent, containing 2.3 per cent $Ca(OH)_2$, but no $CaCO_3$.

1. Materials used: 1000 c.c. solution of bleach = 35 grams Cl; 200 c.c. alcohol, 94 per cent; mixed at 20° C. and distilled. Products obtained: 8.2 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol (distillate A.)

The chloroform reaction commenced at 60 to 65° C. and could easily be observed by the clear solution becoming milky, caused by separation of $Ca(OH)_2$.

The residue remaining in the retort after the distillation contained 8.14 grams $Ca(OH)_2$ by titration, a small part of which was combined with CO_2.

2. Materials used: 1000 c.c. solution of bleach = 35 grams Cl; 700 c.c. distillate A; mixed at 20° C. and distilled. Products obtained: 10.5 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol (distillate B).

The chloroform reaction commenced at 60 to 62° C.

The residue remaining in the retort after distillation contained 7.96 grams $Ca(OH)_2$, some of which was combined with CO_2.

3. Materials used: 1000 c.c. solution of bleach = 35 grams Cl; 700 c.c. distillate B; mixed at 20° C. and distilled. Products obtained: 10.5 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol (distillate C).

The chloroform reaction commenced at 60 to 65° C. and the residue remaining in the retort after distillation contained 7.95 grams $Ca(OH)_2$, combined with a small amount of CO_2.

Experiments Series J, comprising four experiments and representing four days' work in the plant, were made to ascertain the temperature at which the chloroform reaction takes place at various concentrations of alcohol.

The reaction could be observed by the clear solution becoming milky, caused by separation of $Ca(OH)_2$ and the completeness of the reaction could be measured by titrating the contents of the retort for $Ca(OH)_2$ with normal hydrochloric acid on the basis of the experiments in Series K.

Apparatus Fig. 2, used with 2500-c.c. retort.

1. Materials used: 1000 c.c. solution of bleach = 35 grams Cl; 2.3 grams $Ca(OH)_2$; 200 c.c. alcohol, 94 per cent; mixed at 20° C. and slowly heated. Products obtained: 8.2 grams washed chloroform.

The chloroform reaction commenced at 60 to 65° C. and was finished after boiling, the contents of the retort measuring 8.14 grams $Ca(OH)_2$.

2. Materials used: 1000 c.c. solution of bleach = 35 grams Cl, 2.3 grams $Ca(OH)_2$; 1000 c.c. alcohol, 94 per cent; mixed at 20° C. it turned turbid very slowly. Titrated for $Ca(OH)_2$ after standing 24 hours at 20° C., it contained 6.97 grams $Ca(OH)_2$.

3. Materials used: 1000 c.c. solution of bleach = 35 grams Cl, 2.3 grams $Ca(OH)_2$; 1200 c.c. alcohol, 94 per cent, mixed at 20° C., reacted at once, without being heated, and after one hour the contents of the retort measured 6.99 grams $Ca(OH)_2$.

36. *Conclusions from Series I and J.* The temperature at which the chloroform reaction takes place and the time which it requires, depends upon the concentration of the alcohol in the charge.

Approximately 20 per cent alcohol will react with bleach at 60° to 65° C.

Approximately 50 per cent alcohol reacts with bleach at 20° C. within twenty-four hours.

Approximately 55 per cent alcohol reacts with bleach at 20° C. instantly, without application of external heat.

EXPERIMENTS SERIES K, comprising fourteen experiments and representing fourteen days' work in the plant, were made for the purpose of determining the amount of chloroform and $Ca(OH)_2$ formed by repeated reaction of 750 c.c. of a filtered solution of chlorinated lime, containing 35 grams Cl and 1.7 grams $Ca(OH)_2$ on 200 c.c. alcohol, 94 per cent.

No alcohol was added except in the first operation. Apparatus, Fig. 2, was used with 2500-c.c. retort.

The Series is a repetition of Series E[a], carried on to fourteen operations, the difference being that filtered solution of chlorinated lime was used instead of the solid salt, on account of which fact the $Ca(OH)_2$ which was formed by the chloroform reaction could be measured.

1. Materials used: 750 c.c. solution bleach = 35 grams Cl, and 1.7 grams $Ca(OH)_2$; 200 c.c. ethyl alcohol, 94 per cent; 500 c.c. water, mixed at 20° C. and distilled. Products obtained: 7.5 grams washed chloroform, 1.48 s.g.; 700 c.c. diluted alcohol (distillate A). The contents of the retort measured 7.4 grams $Ca(OH)_2$ by titration.

2. Materials used: 750 c.c. solution bleach = 35 grams Cl, 1.7 grams $Ca(OH)_2$; 700 c.c. distillate A; mixed at 20° C. and distilled. Products obtained: 8.2 grams washed chloroform, s.g. 1.48; 700 c.c. diluted alcohol (distillate B). 7.1 grams $Ca(OH)_2$ in contents of retort.

This was repeated to fourteen operations and the results are entered in the following table.

TABLE IX.—EXPERIMENTS SERIES K

Operations. No.	Chloroform washed, s.g. 1.48 obtained. Grams.	$Ca(OH)_2$ in residue in retort. Grams.	$Ca(OH)_2$ in 750 c.c. solution chlorinated lime. Grams.	$Ca(OH)_2$ formed by chloroform reaction. Grams.
1	7.5	7.4	1.7	5.7
2	8.2	7.1	1.7	5.4
3	9.0	7.5	1.7	5.8
4	9.8	7.9	1.7	6.2
5	10.2	7.2	1.7	5.5
6	9.4	7.7	1.7	6.0
7	9.8	7.2	1.7	5.5
8	8.6	7.3	1.7	5.6
9	8.2	6.6	1.7	4.9
10	8.6	7.2	1.7	5.5
11	8.2	7.5	1.7	5.8
12	6.7	6.6	1.7	4.9
13	8.0	7.5	1.7	5.8
14	6.0	7.7	1.7	6.0

37. *Conclusion from Series K.* The amounts of chloroform and calcium hydrate formed in the chloroform reaction are in direct proportion.

EXPERIMENTS SERIES L, comprising twenty-six experiments and representing twenty-six days' work in the plant.

The experiments of Series K were continued with the exception that determinations of lime were omitted after the fourteenth operation, to determine how much chloroform could be obtained from 200 c.c. alcohol used in the first operation. The amounts of chloroform obtained in the subsequent operations are entered into the following table.

TABLE X.—EXPERIMENTS SERIES L

Series L. No.	Bleach 35 per cent used = 35 gr. Cl + 1.7 gr. $Ca(OH)_2$ in 750 c.c. filtered solution. Grams.	Alcohol, 94 per cent present. c.c.	Chloroform 1.48 s.g. obtained. Grams.	Alcohol, 94 per cent, used for chloroform reaction. c.c.	Alcohol, 94 per cent, in after distillate. c.c.
1	100	200	7.5	9.4	190.6
2	100	190.6	8.2	10.3	180.3
3	100	180.3	9.0	11.3	169.0
4	100	169.0	9.8	12.2	156.8
5	100	156.8	10.2	12.7	144.1
6	100	144.1	9.4	11.8	132.3
7	100	132.3	9.8	12.2	120.1
8	100	120.1	8.6	10.8	109.3
9	100	109.3	8.2	10.2	99.1
10	100	99.1	8.6	10.8	88.3
11	100	88.3	8.2	10.2	78.1
12	100	78.1	6.7	8.4	69.7
13	100	69.7	8.0	10.0	59.7
14	100	59.7	6.0	7.5	52.2
15	100	52.2	5.3	6.6	45.6
16	100	45.6	3.8	4.8	40.8
17	100	40.8	4.5	5.6	35.2
18	100	35.2	5.6	7.0	28.2
19	100	28.2	6.0	7.5	20.7
20	100	20.7	5.3	6.6	14.1
21	100	14.1	3.8	4.8	9.3
22	100	9.3	3.4	4.3	5.0
23	100	5.0	1.9	2.4	2.6
24	100	2.6	0.8	1.0	1.6
25	100	1.6	1.1	1.4	0.2
26	100	0.2	0.0	0.2	....
			159.7	200.	

1.25 c.c. alcohol, 94 per cent, made 1 gram chloroform.

38. *Conclusion from Series L.* The amount of alcohol, 94 per cent, used for the chloroform reaction at a concentration of 10 per cent

or more is less than 1250 c.c. of 94 per cent alcohol to 1 kilogram of washed chloroform, or less than 15 gallons alcohol, 94 per cent, for 100 lbs. of chloroform.

EXPERIMENTS SERIES M, comprising ten experiments, representing a run of ten days in the plant and designed for the purpose of determining the amount of alcohol, 94 per cent, used up in successive operations, the concentration of alcohol in the first operation being approximately 10 per cent.

Apparatus Fig. 2 was used, with 2500-c.c. retort.

In each operation 750 c.c. diluted alcohol were distilled which was used in the subsequent operation, together with 1.25 c.c. alcohol, 94 per cent, for every gram of washed chloroform obtained in the previous operation.

1. Materials used: 750 c.c. solution bleach = 35 grams Cl; 150 c.c. alcohol, 94 per cent; 600 c.c. of water; mixed at 20° C. and distilled. Products obtained: 7.8 grams washed chloroform, 1.48 s.g.; 750 c.c. diluted alcohol (distillate A).

2. Materials used: 750 c.c. solution bleach = 35 grams Cl; 10 c.c. alcohol, 94 per cent; 750 c.c. distillate A; mixed at 20° C. and distilled. Products obtained: 9.0 grams washed chloroform, 1.48 s.g.; 750 c.c. diluted alcohol, 94 per cent (distillate B).

This was repeated to ten operations and the results are entered in the following table.

TABLE XI

Operation.	Materials used.				Products.	
	Bleach, 35 per cent. used in filtered solution.		Alcohol, 94 per cent, used.	Diluted alcohol from previous operation.	Chloroform 1.48 s.g. obtained.	Diluted alcohol distilled off after chloroform.
No.	Grams.	c.c.	c.c.	c.c.	Grams.	c.c.
1	100	1350	150	...	7.8	750
2	100	750	10	750	9.0	750
3	100	750	11	750	9.7	750
4	100	750	12	750	9.4	750
5	100	750	12	750	9.0	750
6	100	750	11	750	9.8	750
7	100	750	12	750	9.6	750
8	100	750	12	750	10.1	750
9	100	750	13	750	9.3	750
10	100	750	12	750	9.8	750
	1000	....	255	...	93.5	...

The 750 c.c. diluted alcohol coming from the tenth operation were diluted with an equal volume of water and redistilled with 20 grams hydrated lime, whereby 3.7 grams chloroform were obtained, together with diluted alcohol, containing 161 c.c. alcohol, 94 per cent.

39. *Conclusion.* 1000 grams of bleach, 35 per cent, and 94 c.c. of alcohol, 94 per cent, had, therefore, made 97.2 grams of washed chloroform 1.48 s.g. The amount of alcohol, 94 per cent, used for the chloroform reaction, at a continuous concentration of 10 per cent, is approximately 968 c.c. for 1000 grams washed chloroform 1.48 s.g., or not quite 1 c.c. alcohol, 94 per cent, for 1 gram of chloroform.

EXPERIMENTS SERIES N, comprising ten experiments and representing a run of ten days in the plant. This series is a repetition of Series M, except that the materials were mixed near boiling-point. (Compare Experiments Series G.)

Apparatus Fig. 1 was used, with 2500-c.c. retort, carrying a long stem funnel, reaching toward the bottom of the retort.

The diluted alcohol was charged into the retort and heated to boiling, whereupon the solution of bleaching powder was poured, in small portions, through the long stem funnel, into the alcohol which was boiling in the retort.

The quantities of materials used were the same as in Series M, except that fresh alcohol, 94 per cent, was added at the rate of 1 c.c. alcohol, 94 per cent, for every gram chloroform obtained in the previous operation. (See conclusion 39.)

The results of ten operations are entered in the following table.

TABLE XII

Operation.	Materials used.				Products.	
	Bleach 35 per cent used in filtered solution.		Alcohol 94 per cent used.	Diluted alcohol from previous operation.	Chloroform 1.48 s.g. obtained.	Diluted alcohol distilled off after chloroform.
No.	Grams.	c.c.	c.c.	c.c.	Grams.	c.c.
1	100	1350	150	...	7.2	750
2	100	750	7	750	9.8	750
3	100	750	10	750	10.4	750
4	100	750	10	750	10.8	750
5	100	750	11	750	10.9	750
6	100	750	11	750	10.2	750
7	100	750	10	750	11.0	750
8	100	750	11	750	10.8	750
9	100	750	11	750	11.0	750
10	100	750	11	750	10.6	750
	1000	....	242	...	102.7	...

The 750 c.c. diluted alcohol coming from the tenth operation were treated in the same manner as described in Series M, whereby 3.2 c.c. chloroform, 1.48 s.g., and 146 c.c. alcohol, 94 per cent, were obtained.

40. *Conclusion.* 1000 grams bleach, 35 per cent, and 96 c.c.

alcohol, 94 per cent, had, therefore, made 105.9 grams of washed chloroform, 1.48 s.g., which would make 103.4 grams pure chloroform after washing with sulphuric acid 66° and redistilling. The amount of alcohol, 94 per cent, used for the chloroform reaction, at a continuous concentration of 10 per cent, is approximately 928 c.c. alcohol, 94 per cent, for 1 kg. of pure chloroform.

This work done, the most favorable conditions were figured from the conclusions Nos. 1 to 40, drawn from 126 experiments, which represent 126 days' work in the plant. They were found to be as follows, viz.:

1st. The concentration of alcohol in the charge was to be about 10 per cent.

2d. There was to be not less than 100 c.c. alcohol, 94 per cent, present for every 100 grams of bleach, 35 per cent.

3d. The alcohol and the solution of bleaching powder was to be brought together at boiling-point, or as near to it as possible.

If these conditions could be given in the plant, 100 lbs. pure chloroform could be expected from 967 lbs. bleach, 35 per cent, and 11.1 gallons alcohol, 94 per cent (see experiments Series N), in place of from 1510 lbs. bleach, $33\frac{1}{3}$ per cent, and 11.73 gallons alcohol, 94 per cent, which were obtained as an average, in the manufacture of 100,257 lbs. chloroform in actual practice. (See page 142). While the consumption of alcohol was about the same as in the old process, the saving in bleaching powder was approximately 34 per cent.

In order to comply with these requirements one old apparatus, represented in Fig. 1, was changed as indicated in Fig. 3, by closing up the manhole in the still and riveting to the top of the still, a funnel (*a*) in the center of which a 4-in. pipe reached down toward the bottom of the still. In place of a square box which, in the old process, had served for dissolving the bleaching powder, a round agitating apparatus, *A*, was installed, in which the bleaching powder was more readily dissolved in the necessary amount of water. The receiver, *D*, taking the chloroform and diluted alcohol, which ran from the cooler, was changed to the form indicated in the drawing and a receiving tank, *E*, capable of holding 400 gallons of diluted alcohol, was set in the ground under the receiver, for the purpose of storing the diluted alcohol distilled in one operation. The bottom of the receiving tank was connected by a 1-in. pipe with the upper part of still, *B*, and by air pressure, the contents of the receiver

could be blown out, into the still as soon as the latter was ready for a new operation.

The apparatus was operated in the following manner:

120 gallons alcohol, 94 per cent, were charged into still *B*, Fig. 3, and sufficient water added to make the alcohol about 20 per cent. This would fill the still about 2 ft. One cask bleaching powder,

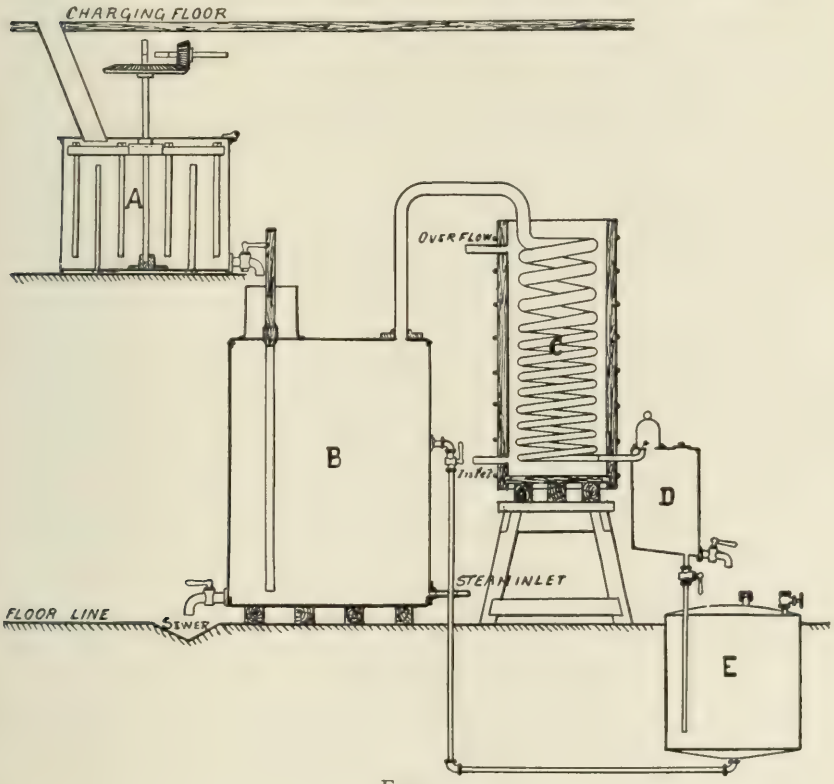


FIG 3.

holding about 1000 lbs. was charged into agitator, *A*, containing sufficient water to fill the agitating vessel to within 6 ins. from the top. Then the diluted alcohol was heated by direct steam to boiling, and the solution of bleaching powder was introduced into *B*, in small quantities, through the funnel tube, *a*.

The reaction would take place at once and the chloroform would distill freely, together with some alcohol. When all the bleaching

powder was introduced, the chloroform, and subsequently the alcohol, were distilled off, about 400 gallons of diluted alcohol being obtained in each operation.

The diluted alcohol thus obtained was used for the subsequent charge and sufficient fresh alcohol, 94 per cent, was added to make up for the alcohol which had been converted into chloroform in the previous operation. With this alcohol and another 1000 lbs. bleaching powder, dissolved in sufficient water to fill the agitating tank, *A*, to within 6 ins. from the top, the operation was repeated once a day and chloroform was thus obtained in a continuous run.

A run of six days was made with this improved apparatus, with the following results, viz.,

TABLE XIII

Day.	Bleaching powder used.				Alcohol, 94 per cent used.	Chloroform 1.48 s.g. obtained.	1000 lbs. bleach 35 per cent made chloroform, 1.48 s.g.
	Bought for		Equal to				
No.	Lbs.	Per cent. Cl.	Lbs.	Per cent. Cl.	U. S. gal.	Lbs.	Lbs.
1	1129	31	1000	35	120	81	81
2	1129	31	1000	35	10	100	100
3	1129	31	1000	35	10	102	102
4	1129	31	1000	35	10	108	108
5	1129	31	1000	35	10	106	106
6	1129	31	1000	35	10	105	105
			4000	35	...	421	105
	Proportion.....		1000 952	35	...	...	105 100

Not counting the first two days, in which the previous charges have an influence upon the yield, an average of 105 lbs. washed chloroform, 1.48 s.g., were obtained from 1000 lbs. bleach 35 per cent.

An attempt was made to increase the capacity of the plant, by charging 1500 lbs. of bleach, 35 per cent, into agitator *A* for each charge, adding sufficient water to make the same volume of solution as in the previous run and using this more concentrated solution of bleach in the same manner as the weaker solution in the previous work.

A run of six days, with 1500 lbs. bleaching powder for each charge was made, with the following result, viz.:

TABLE XIV

Day.	Bleaching powder used.				Alcohol 94 per cent used.	Chloroform 1.48 s.g. obtained.	1000 lbs. bleach 35 per cent made chloroform 1.48 s.g.
	Bought for		Equal to				
No.	Lbs.	Per cent. Cl.	Lbs.	Per cent. Cl.	U. S. gal.	Lbs.	Lbs.
1	1694	31	1500	35	120	125	83
2	1694	31	1500	35	15	147	98
3	1694	31	1500	35	15	159	106
4	1694	31	1500	35	15	158	105
5	1694	31	1500	35	15	153	102
6	1694	31	1500	35	15	159	106
			6000	35	...	629	105
	Proportion.....		1000	...	...	...	105
			952	...	...	...	100

Since the works ran smoothly, the contents of the apparatus not boiling over and since still *B* was less than three-quarters filled at the completion of the charge, the larger charge was thought possible in the regular run, whereby the capacity of the plant was increased by 50 per cent.

In making this run it was observed that the first thousand pounds bleach made more chloroform proportionately than the following 500 lbs. In Exps. Nos. 3 to 6, 113, 116, 113, 116 lbs. washed chloroform, respectively, were obtained from the first thousand pounds bleach, 35 per cent, while 47, 40, 40, 45 lbs., respectively, were obtained from the following 500 pounds.

From this observation it might be concluded that greater concentration of alcohol would produce a still greater yield. But the advantage did not seem sufficiently large to justify the increased consumption of steam and the decrease of the capacity of the plant, and for this reason experiments in this direction were not carried on.

Following these runs, all six apparatus were changed in the same manner and they were operated parallel with bleaching powder, 31 per cent to 37 per cent, for several years. From time to time, operations were discontinued to make calculations, or for other reasons, and the following are the results obtained from several lots. In every instance, the diluted alcohol obtained in the last operation was redistilled with calcium hydrate, and the amount of alcohol

obtained was deducted from the amount of alcohol used in the aggregate operations, the difference being the alcohol, 94 per cent, used up for chloroform.

TABLE XV

Day. No.	Bleach 35 per cent used. Lbs.	Alcohol 94 per cent used. U. S. gal.	Chloroform 1.48 s.g. obtained. Lbs.	1000 lbs. bleach 35 per cent made chloroform. Lbs.
1	6,322	559	510	81
2	9,055	90	940	103
3	9,160	120	959	104
4	9,011	120	931	103
5	9,196	90	968	105
6	9,125	120	942	103
7	9,075	120	949	104
8	9,503	90	1,039	109
9	9,268	90	967	104
10	9,206	90	930	101
11	9,100	90	943	104
12	9,221	120	924	100
13	9,172	120	954	104
14	9,157	120	987	108
15	9,274	120	1,001	108
16	9,240	120	927	101
17	9,254	120	967	104
18	9,352	90	942	100
19	9,160	120	969	105
20	9,263	120	1,001	108
21	9,146	90	977	106
22	9,107	120	1,016	101
23	9,311	90	984	105
24	9,327	120	985	103
25	9,106	120	1,029	103
26	9,154	90	970	106
27	9,207	120	968	105
28	9,140	120	957	105
29	9,072	100	949	105
30	7,576	120	838	100
31	9,632	90	1,013	105
32	9,047	120	993	100
33	9,556	152	990	103
	299,525	4,081	31,419	105

Record of a thirty-three days' run, with 35 per cent bleach, showed the daily variations. On every day, except the thirtieth day, six apparatus were used, while on the thirtieth day, only five were in commission, one being in repair. One and one-half casks

bleach, 35 per cent, weighing about 1500 lbs., were used for a charge in each apparatus in every day's run except on the first day, when only one cask per apparatus was charged.

The diluted alcohol, coming from the last operation, contained 640 gallons alcohol, 94 per cent, and from the 31,419 lbs. washed chloroform, 30,675 lbs. pure chloroform was obtained. The net result of the run was, therefore, that 299,525 lbs. bleach, 35 per cent, and 3441 gallons alcohol, 94 per cent, made 30,675 lbs. pure chloroform, which is equivalent to 102.4 lbs. pure chloroform from 1000 lbs. bleach, 35 per cent, and 11.49 gallons alcohol, 94 per cent, or, 100 lbs. pure chloroform required 977 lbs. bleach, 35 per cent, and 11.22 gallons alcohol, 94 per cent.

Record of 8 lots chloroform, made from bleach containing 31 to 37 per cent chlorine and alcohol, showing variations by different strengths of bleach.

TABLE XVI

Lot.	Bleaching powder used.				Alcohol 94 per cent used.	Chloroform obtained.	
	Bought for		Equal to			Crude, 1.48 s.g.	Pure.
No.	Lbs.	Per cent. Cl.	Lbs.	Per cent. Cl.	U. S. gal.	Lbs.	Lbs.
1	353,375	32	323,085	35	3,710	30,155	29,446
2	53,968	32	49,342	35	536	4,244	4,046
3	185,414	35	185,414	35	1,930	16,065	15,982
4	299,525	35	299,525	35	3,441	31,419	30,675
5	168,178	31	148,958	35	1,732	15,373	14,925
6	83,218	37	87,973	35	880	8,279	8,182
7	577,871	35	577,871	35	6,646	62,595	61,124
8	799,387	35	799,387	35	9,013	77,916	77,551
			2,471,555	35	27,888	246,046	241,931
	Proportions.....		1,000 1,022	35	11.28 11.53	99.5	97.9 100.0

Comparing this with the results obtained by the old process and recorded on page No. 8, a saving of .20 gallon alcohol, 94 per cent, and 415 lbs. bleaching powder, 35 per cent, was effected for every 100 lbs. of chloroform made by the new process.

The saving in alcohol was insignificant, but there was no saving expected, the experiments indicating the consumption of 11.5 gallons

alcohol for every 100 lbs. of chloroform, while 11.53 gallons were used in actual work. The gain in bleaching powder, however, was 29 per cent, quite near to the 34 per cent saving, which were indicated by the most favorable experiments in Series N. The consumption of steam was larger than in the old process, since about 400 gallons diluted alcohol were to be distilled off in each operation, in order to recover all the alcohol. About 3 tons steam were required for each apparatus, in a day's work. However, 1500 lbs. bleach could be worked daily, in each of the six stills, in place of 1000 lbs. and 147 lbs. pure chloroform were manufactured per day in each still, in place of 70 lbs., which could be made by the old process, an increase in capacity of the plant of over 100 per cent.

The amount of steam used by the new process was 2 tons for 100 lbs. chloroform, against 1.1 tons in the old process, for the same amount.

The same number of laborers ran the improved plant, after mechanical washers had been installed, the same laborers making more than twice the former product.

There are localities in the Western States, where corn, limestone and salt are cheap, where coal and power are abundant. There may be a market for caustic soda but none for bleach, which cannot be disposed of on account of the freight rates. By making chloroform, many pounds of material can be condensed into one and can be shipped to the centers of population.

Discussion

Before I read the second paper on laboratory apparatus, I will be glad to answer any questions that anyone would like to ask.

Dr. Sadtler:

I would like to ask with regard to testing for the side-products in the chloroform obtained. Chloroform obtained from alcohol, as discussed by you, is formed in several steps: first by oxidation, yielding aldehyde; then by chlorination producing alcohol, and the bleach containing free lime produces the chloroform. These three steps are necessary so that when you come to purify it there is a very considerable action upon sulphuric acid. Now in making chloroform from acetone you can produce it in one reaction and the theoretical yield is 210 per cent, and I have seen it obtained in practice at the Perth Amboy factory yielding 206 per cent, and it hardly

blackens sulphuric acid; so it seems to me that in making alcohol with acetone you get not only a greater yield but a relatively greater purity. It is quite well known that you cannot always produce chloroform that is pure enough for anæsthesia. Now I would like to ask if the purity of the chloroform is established and the freedom from these foreign products?

Dr. FRERICHS:

I have also made a good deal of chloroform from acetone. Chloroform made from alcohol is easily purified by sulphuric acid. This is not the case with chloroform made from acetone. Acetone itself or chloroform which is obtained from acetone, may not discolor sulphuric acid very much, but there are substances in the chloroform made from acetone which are very difficult to remove. If the tests for purity are employed, using sulphuric acid 66 degrees, slight discoloration will set in after some time in acetone chloroform, while in alcohol chloroform, discoloration will not occur. I experienced very great difficulty in purifying chloroform from acetone, and have used for purifying three or four times the amount of sulphuric acid which I needed for alcohol chloroform. It seems that these substances go into sulphuric acid but do not discolor it.

A MEMBER:

It seems to me that the acetone as made by you and rectified was of such purity that it was free from those ketones.

Dr. FRERICHS:

I have not rectified the acetone as thoroughly as other manufacturers may do.

Dr. SADTLER:

I was going to say that in the factory of the Roessler & Hasslacher Chemical Co., of Perth Amboy, N. J., they use the greatest care to get rid of other ketones. Now with acetone I have never found sulphuric acid to give any appreciable color, even with long standing.

Dr. FRERICHS:

Well, it should not give any color at all, and if chloroform made from alcohol is properly purified, sulphuric acid will not give any discoloration, even after standing for a week.

CONSTRUCTION OF LABORATORY APPARATUS

This paper describes briefly a number of pieces of special apparatus which were devised to facilitate laboratory work, increasing accuracy and saving time. All of these devices have already been published, and therefore, reference to the literature will be given where the full descriptions may be found.

The well-known Sartorius balance was devised by Dr. Frerichs while he was a student in the university, working in quantitative analysis. The original description of this balance was published in Liebig's *Annalen*, volume 178, page 365, thirty-one years thereafter at the World's Fair in St. Louis. The gold medal for collaboration in constructing the Saratorius balance was presented to Dr. Frerichs.

A torsion balance was also devised by Dr. Frerichs and patented in Germany. The description of this balance is found in Liebig's *Annalen*, volume 178, page 368.

An apparatus was designed for quantitative analytical work on the principle of the ordinary filter press. This device materially shortened the time required for filtering and washing of quantitative precipitates. This apparatus is described in Liebig's *Annalen*, volume 185, page 193.

A somewhat larger apparatus was designed for qualitative work and for making chemical praparations. It is made of china clay and is manufactured by the Royal Porcelain Manufactory in Berlin, Germany.

An apparatus for the determination of vapor density was also devised. A description of this apparatus is published in Liebig's *Annalen*, volume 185, page 199.

MANUFACTURE AND TESTING OF SHIPPING CYLINDERS FOR ANHYDROUS AMMONIA

By F. W. FRERICHS

Read at the Washington Meeting, Dec. 20, 1911

All chemical manufacturers produce goods and these goods need packages in order to be marketed. The question of packages is often more difficult and requires more study and capital than the manufacture of the goods to be shipped in them, and this is particularly the case if the packages are intended for compressed or liquefied gases, which can only be handled with reasonable safety if the containers in which the gases are confined are constructed and kept in such a manner that danger in handling them as far as practicable is excluded.

Manufacture of Valves

It is often said that the manufacture of packages is not a chemical problem and chemists should not meddle with questions outside of their line; that if questions of packages arise they should go to men who make them and take their advice. But there are instances in which the chemical engineer is confronted with the necessity of going himself into the manufacture of containers and in such cases, the manufacture of packages becomes a chemical engineering problem. I experienced a case of that kind not long ago when I needed a large number of valves for ammonia shipping cylinders, and since the object involved many thousands of dollars, I went to the trouble of studying the question thoroughly.

I made designs and had models made at great expense, some of which you see among the exhibits.

When I had produced a model which seemed to fill my requirements, I selected a shop where similar work had been done and contracted at their price for 1500 valves, equal to the model submitted. When deliveries were begun I had to reject every valve. When the defects were pointed out it was admitted that the differences were there, but it was contended that the valves delivered were just as

good and answered the purpose. To this I took exceptions. As the proprietors of the shop were desirous of fulfilling their contract, I went into their shop to help things along, and investigated the cause of the unsatisfactory work which had been delivered.

The drop forgings for the valve bodies were made by a reliable firm on my direct order. There was no trouble on this account and

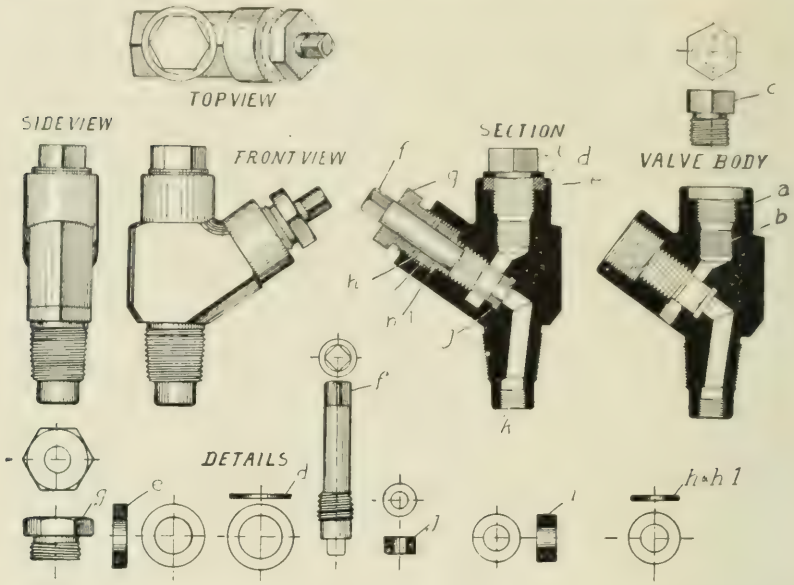


FIG. 1.—Valve for Ammonia Cylinders. *a*, $\frac{1}{2}$-in. pipe connection; *b*, $\frac{3}{8}$-in. pipe connection; *c*, plug; *d*, iron washer; *e*, rubber washer; *f*, valve stem; *g*, stuffing-box nut or gland; *h* and *h'*, iron washers; *i*, packing; *j*, soft metal seat; *k*, pipe connection for dipper pipe.

the valve stems and the nuts were made from standard steel bars, so that there could be no fault with the material.

In the shop I found some good and some worn machine tools, and there were some good machinists, but the majority of the help were second-class man. Since work was continously coming in it was necessary to shift my work from one place to another to keep the shop going, and the result was unsatisfactory work.

The valve stems and lock nuts had been sublet to another shop of good reputation at a contract price, but they were turned out on

a much-used screw machine, were therefore not accurately made, and were not satisfactory to me.

For making good valves, perfect tools and good mechanics seemed to be necessary and in order to turn them out at the rate of about 200 valves per week, by my calculation, a sum of about $3000 was to be invested in tools. The shop was unwilling to make such an investment. Neither could they promise to put only first-class machinists on the work, unless I would agree to pay a price which was prohibitive.

In this manner, I was forced to undertake the work myself. I bought the best machine tools I could obtain, and arranged a shop containing two screw machines, two lathes, two drill presses, one gas furnace for case hardening and one power hack saw and emery wheel, all of which cost about $3000. I employed three good machinists and two helpers, put one of my engineers in charge of the shop and turned out 180 good valves per week at a cost which was much less than the price which I had paid to the outside shop for unsatisfactory work.

I have run the shop for about a year, have made about 8000 valves and if I sell to-day the machine tools at two-thirds their cost, I have gained about $4000 on the transaction, having at the same time a valve which is satisfactory to me.

Manufacture of Welded Shipping Cylinders

Compressed and liquefied gases are manufactured in very large quantities and for their safe transportation by common carriers, rules have been adopted in many countries for constructing and testing containers in which they may be accepted for shipment by transportation companies.

Containers used for this purpose generally have the form of cylinders.

One set of rules has been agreed upon by the railroads of Germany, Austria-Hungary, Belgium, France, Denmark, Italy, Luxemburg, the Netherlands, Roumania, Russia, Sweden, and Switzerland, which rules are commonly referred to as the International Rules for European countries. Up to recent times there were, however, no regulations of this kind in the United States, but the American Railroad Association, in conjunction with committees appointed by manufacturers of compressed gases, have been working on such rules

for several years and these rules were recently adopted by the Interstate Commerce Commission of the United States, and went into effect October 1, 1911.

The general rules, applying now to shipping containers for compressed and liquefied gases, are as follows:

"(*a*) Gases that may combine chemically must not be shipped in one cylinder. Cylinders purchased hereafter for the shipment of compressed gases must be made in accordance with specifications approved by the Interstate Commerce Commission.

"(*b*) By water jacket, or other suitable tests, each cylinder used for shipping liquefied gases must be subjected at least once in five years to a uniform interior pressure not less than one and one-quarter times the interior pressure that would result from heating the cylinder uniformly, in its maximum charged condition, to a temperature of 130° F. Each cylinder used for shipping under pressure not exceeding 1000 lbs. per square inch non-liquefied gases or gases in solution, must be subjected at least once in five years to a uniform interior pressure not less than twice the charging pressure for such cylinder, corresponding to a temperature of 70° F.; when the charging pressure exceeds 1000 lbs. per square inch, the test pressure must not be less than one and one-half times the charging pressure. A cylinder must be condemned when it leaks, when the permanent expansion is due to local weakness, or when it is uniform and exceeds 5 per cent of the total expansion. When the charging pressure is less than 300 lbs. per square inch it will not be necessary to measure the permanent expansion in quintennial pressure tests, provided the cylinder in question has previously passed this test.

"(*c*) The weight of gas charged into any cylinder must not at a temperature of 130° F. cause an interior pressure in excess of three-fourths of the elastic limit of the weakest part of the cylinder.

"(*d*) The manufacturer must not offer for transportation a cylinder filled with such charging density of any gas as would produce failure in the test prescribed for that gas.

"(*e*) After December 31, 1914, all cylinders must plainly be stamped with the date of last test—for example, '4–09' for April, 1909—or otherwise durably marked to show compliance with this rule; and by December 31, 1911, not less than one-fourth of the cylinders in use for shipping purposes must be thus tested and marked.

"(*f*) Cylinders containing acetylene gas must be made of tough steel and must be completely filled with a porous material that has

been tested by the Bureau of Explosives and approved by the Interstate Commerce Commission, and this material must be charged with acetone or its equivalent not to exceed 40 per cent of the interior volume capacity of the cylinder. The pressure in cylinders containing acetylene gas must not exceed 250 lbs. per square inch at a temperature of 70° F."

In addition to these general rules, specifications for shipping containers are adopted, each set of specifications being different for different gases. The specifications for lap welded cylinders intended for shipping anhydrous ammonia, run as follows:

Interstate Commerce Commission, Washington, D. C. Regulations for the transportation of dangerous articles other than explosives.

Shipping container specification No. 4. Lap welded steel cylinders for anhydrous ammonia.

Revised.....Jan. 1, 1912. Effective .....March 31, 1912

1. TABLE OF DETAILS AS TO DIMENSIONS

Outside Diam. of Cylinder.	Overall Length of Cylinder.	Nominal Thickness of Cylinder.	Test Pressure in Lbs. per Sq. in.	Head			Mouth.			Weight of Cylinder in Pounds.	
				Depth	Low Limit.	High Limit.	Diameter.	Low Limit.	High Limit.	Low Limit.	High Limit.
10″	3′ 10″	.19″	1000	$3\frac{3}{4}$″	$3\frac{9}{16}$″	$3\frac{15}{16}$″	$7\frac{1}{2}$″	$7\frac{3}{8}$″	$7\frac{5}{8}$″	87	112
10	4 0	.19	1000	$3\frac{3}{4}$	$3\frac{9}{16}$	$3\frac{15}{16}$	$7\frac{1}{2}$	$7\frac{3}{8}$	$7\frac{5}{8}$	90	115
10	7 0	.19	1000	$3\frac{3}{4}$	$3\frac{9}{16}$	$3\frac{15}{16}$	$7\frac{1}{2}$	$7\frac{3}{8}$	$7\frac{5}{8}$	150	175
10	3 10	.27	1500	$3\frac{3}{4}$	$3\frac{9}{16}$	$3\frac{15}{16}$	$7\frac{1}{2}$	$7\frac{3}{8}$	$7\frac{5}{8}$	113	141
10	4 0	.27	1500	$3\frac{3}{4}$	$3\frac{9}{16}$	$3\frac{15}{16}$	$7\frac{1}{2}$	$7\frac{3}{8}$	$7\frac{5}{8}$	117	145
10	7 0	.27	1500	$3\frac{3}{4}$	$3\frac{9}{16}$	$3\frac{15}{16}$	$7\frac{1}{2}$	$7\frac{3}{8}$	$7\frac{5}{8}$	203	237
12	7 0	.21	1000	$3\frac{5}{4}$	$3\frac{9}{16}$	$3\frac{15}{16}$	9	9	$9\frac{1}{4}$	220	250

2. Cylinders must be manufactured from lap welded pipe, made of soft steel of the best welding quality, free from blisters, cracks or other injurious defects.

Inspection and testing of Material

3. The pipe intended for these cylinders must be manufactured by the best appliances and according to the best modern practice, each length to be inspected separately for defects inside and outside and then subjected to the following tests:

(*a*) To each crop end cut from the pipe from which the cylinders are to be made a flattening test must be applied with the weld 45° away from the side which is subject to the greatest bending stress, with knife edges of wedge shape converging at an angle of 60°, the point being rounded off with a radius of $\frac{1}{2}$ in. In this test the crushing of the walls must be to within four times the thickness of the metal, and a crop end must withstand the test without cracking.

(*b*) An internal hydrostatic test of 600 lbs. per square inch must be applied to each length of pipe, under which it must not show signs of leaking at the weld or elsewhere.

4. Each finished cylinder must be tested by internal hydrostatic pressure as specified in above Table, Par. 1, the test to be conducted as follows:

(*a*) After filling cylinder with water the test pressure specified must be applied for the purpose of detecting leaks and rounding up the cylinder.

(*b*) The cylinder, if tight, must be placed in a water jacket, or other approved apparatus for measuring the expansion, and the test pressure again applied. The permanent expansion under this test must not exceed 10 per cent of the whole volumetric expansion at the pressure specified.

General Construction and Inspection

5. The manufacture of the cylinders must be completed with the best appliances and according to the best modern methods. All finished cylinders must show a reasonably smooth surface, and must have passed the above inspection and tests without showing any defect in workmanship or material likely to result in any appreciable weakness in the finished cylinder. Each completed cylinder must be inspected for such defects at the mill by the purchaser or his representatives before acceptance.

These rules and specifications are the results of extensive tests made with cylinders taken from the present equipment of the various manufacturers and with new cylinders made for the specific purpose of testing.

It gives me great pleasure to say right here, that tests have shown the shipping cylinders of old equipment generally to be of greater strength than required by the regulations, from which fact it may be

concluded that manufacturers always have been anxious to make shipping cylinders of ample strength so that accidents might be prevented.

By these regulations, containers for liquefied gases must be safe at pressures to which the fully charged cylinders will be exposed at 130° F. and the following table gives the pressures corresponding to various temperatures for some liquefied gases most commonly handled.

TABLE I

	Absolute Pressure at			Test Pressure, Absolute.			Critical Pressure Absolute.		Critical Temperature.	
				American Rules.	International and German Rules					
	15° C. 59° F.	38° C. 100°F.	55° C. 130°F.	Lbs.	Lbs.	Atm.	Lbs.	Atm.	° C.	° F.
Carbon dioxide...	768	1160	1227	2454	2793	190	1132	77	31.1	88
Nitrous oxide....	732	1112	1180	2360	2646	180	1103	75	35.4	96
Ammonia.....	104	215	340	425	441	30	1690	115	130.0	266
Chlorine.....	85	156	250	312	323	22	1374	93.5	145.4	294
Sulphur dioxide..	40	...	147	184	176	12	1160	78.9	155.4	312

From this table it is seen that the pressures vary greatly with the different gases and, consequently, shipping cylinders used for different gases must be of different strengths.

From the table it is also evident that, in a general way, the International and American rules agree fairly well, and we will now have to see in which way the shipping cylinders must be constructed in order to comply at the same time with the rules of the railroad companies, which are considered by them necessary to secure safe handling; with the interests of the mills, which require that the specifications be inside of the possibility of manufacture at a minimum cost; and with the interests of manufacturers and consumers of the goods, which make it desirable that the shipping cylinders be as light as possible in order to facilitate the handling and securing the lowest freights.

In designing shipping cylinders, the first question is, which metal can be used and what must be the strength and thickness of the

material of the container to withstand the pressure to which the cylinder will be subjected.

The answer to this question is found by the following considerations:

Materials used for construction of shipping cylinders must be indifferent to the gases which are to be shipped in them.

All materials have constant properties, among them, ductility, the tensile or breaking strength, and an elastic limit.

A bar of any material, having a cross-section of one square inch, subjected to a moderate strain, will elongate and spring back to its initial length when the strain is released. This indicates the elasticity of the material. If, in repeating the experiment, the strain is increased, a point will be reached at which the bar does not spring back to its original length, and the strain at which this takes place is the elastic limit of the material. If the strain is increased beyond the elastic limit the bar will be disrupted and the strain at which disruption takes place is the breaking strain of the material.

The toughness or ductility of a material is tested by bending a strip of it and looking for cracks on the bend. It is accepted that a cylinder made of material which complies with this bending test, will not break up into flying fragments if it explodes by the influence of internal gas pressure.

From the values of the breaking strain and the elastic limit of materials, the dimensions of shipping cylinders may be computed.

In a cylinder, filled with compressed gas, the strain is two-fold, namely, in the direction of the longitudinal axis of the cylinder and at right angle to this direction.

Given a cylinder of 10 ins. diameter, filled with gas under 100 lbs. pressure to the square inch, the total pressure on each of the circular ends is equal to the area of 10-in. circular plane, expressed in square inches, multiplied by 100 lbs., which is equal to 7584 lbs. Since this stress must be taken up by the sides of the cylinder in the circumferential seam, between the bottom of the cylinder and its sides, each inch of the circumference (which measures 31.4 ins.) must withstand a stress of 7584 divided by 31.4, equal to 241 lbs.

The stress in the material at right angles to this direction is equal to the charging pressure on a plane which is passed through the longitudinal axis and confined by the sides of the cylinder.

Assuming again the charging pressure to be 100 lbs. per square inch, then the strain on two opposite sections in the sides of

the cylinder, each section 1 in. long and of the thickness of the material, is equal to the same pressure of 100 lbs. on a plane of 1 in. width and in length equal to the diameter of the cylinder. This is in our case, 100 times 10 or 1000 lbs.

One-half of this stress is taken up on each of the ends of the plane or what is the same in each line of the cylindrical part of the container which is parallel to the axis of the cylinder and 1 in. long, which in our case is 500 lbs. This stress, being greater than the stress in the direction of the axis, must govern in the calculation of the cylinder.

If the cylinder is made of steel and assuming the tensile strength of the material to be 50,000 lbs. to the square inch, with an elastic limit of 30,000 lbs., then the tubular part of the cylinder must have a thickness, expressed in inches, equal to 500, divided by 30,000, or $\frac{1}{60}$ of an inch, in order to withstand an interior pressure of 100 lbs. to the square inch and straining the sides not beyond the elastic limit of the material. For the heads, the required thickness of the material is the same as for the sides, if the heads have the form of a convex hemisphere. If the heads are flat or concave, the thickness is not easily figured, since it depends upon the form of the head and the bending strength of the material, which in the same material is subjected to considerable variation.

There are two kinds of pipe steel manufactured at the present time. The highest grade steel has a breaking strength of from 65,000 to 150,000 lbs., with an elastic limit of 40,000 to 110,000 lbs.

The chemical analysis of a sample of steel, having 50,000 lbs. elastic limit was, carbon 0.55 per cent, phosphorus 0.05 per cent, sulphur 0.04 per cent, but this steel does not weld and can only be used for the manufacture of seamless tubes.

An inferior grade of pipe steel now commonly used, has a breaking strength of 50,000 to 55,000l bs., with an elastic limit of about 30,000 lbs. Two analyses of this kind of steel have given the following results:

S.	P.	Mn.	C.
0.061%	0.095%	0.25%	0.08%
0.068	0.121	0.42	0.08

This steel can be welded, can be bent over to four times its thickness without cracking in the bend and furnishes at present the material for welded tubes and cylinders.

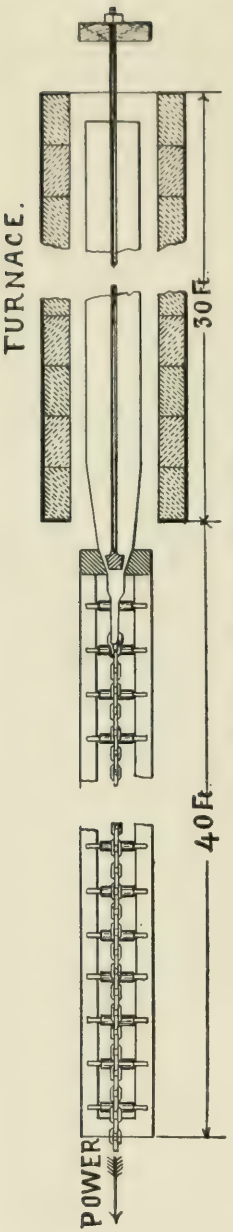


FIG. 2.—Making Welded Steel Tubes.

Up to about fifteen years ago, manganese was not commonly used as an ingredient for pipe steel and an increased amount of phosphorus was at that time left in the steel to give it welding qualities. Such steel has a low breaking strength of about 40,000 to 45,000 lbs., with a comparatively high elastic limit of about 30,000 lbs. Two analyses of this steel have given the following results:

S.	P.	Mn.	C.
0.031%	0.292%	Trace	0.06%
0.032	0.293	"	0.06

This steel welds but breaks on bending, for which reason its manufacture is abandoned.

If the necessary strengths of shipping cylinders for the various gases are figured from the values given in the table on page 181, it will be found that carbonic acid, nitrous oxide and oxygen (under 1500 lbs. pressure) require cylinders made of steel of high tensile strength, while cylinders for ammonia and compressed air (under 600 lbs. pressure) for railroad cars and for many other gases, can be made from steel of less strength.

Bearing in mind that steel of high tensile strength cannot be welded, while steel of less strength has welding qualities, the manufacture of steel cylinders in this country is carried out in two different ways.

Cylinders made from high grade steel are made by the seamless method. This class of cylinders is represented by carbonic acid cylinders and cylinders for nitrous oxide gas and oxygen.

The second type of shipping cylinders is made from steel of less strength which has welding qualities, and this type of

cylinders is used for liquefied ammonia gas and compressed air, under less than 600 lbs. pressure.

Their mode of manufacture is a follows: A sheet of steel, about 25 ft. long and of a width equal to about $3\frac{1}{4}$ times the diameter of the tube which is to be made, is heated in a furnace, Fig. 2, to welding heat, whereupon it is drawn over a core through a round die,

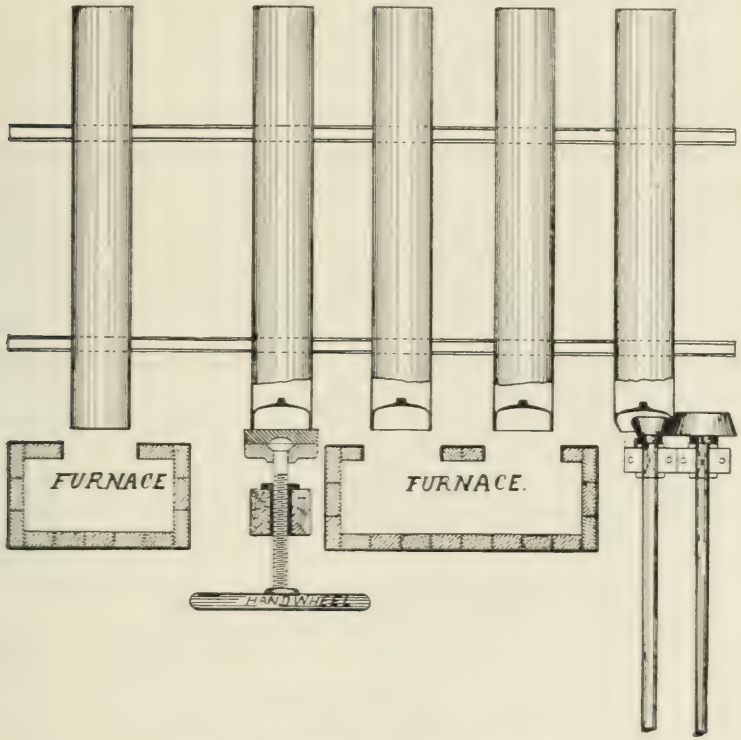


FIG. 3.—Welding Heads into Cylinders.

forming a tube of such diameter that the edges of the sheet overlap one another and by pulling the sheet with great force over the core and through the die, the weld is pressed together so that it does not exceed in thickness the original plate. Cutting off the crop ends from the tube, a length of about 22 ft. is obtained which is put into the testing bench, in which both ends of the tube are closed by suitable pistons. This done, water under about 600 lbs. pressure is applied to the interior of the tube, whereby leaks may be detected and whereby

the entire tube is rounded out into a uniform shape. If the tube has proved sound, it is cut in suitable lengths, which serve for the manufacture of shipping cylinders.

Circular plates are cut for the heads and while hot are dished and flanged in a suitable press.

A boss is welded to the center of one head for each cylinder, to give sufficient metal for the hole receiving the valve and the heads are pressed into the ends of the cylinders, heated to a welding point, pressed together and flared between conical rollers, as shown in Fig. 3, whereupon the cylinders are ready for testing.

The testing includes an inspection for visible defects, the ascer-

FIG. 4.—Testing Samples for Ductility.

taining of their length, diameter and weight, a test of the material for ductility and strength, and the test of the finished cylinder by pressure test.

For the test of ductility of the material, the crop ends may be used which constitute the waste in cutting tubes for cylinders to length. The test for ductility is made by bending test strips to four times the thickness of the material, whereupon no cracks must be visible on the bends. Fig. 4.

The test for strength of the material may be made by cutting test strips from the crop ends, finishing them as indicated in Fig. 5, and pulling them in a testing machine to destruction. If waste material has not been saved in cutting pipes, a number of cylinders, say one out of 200, are cut up for the purpose of obtaining test pieces.

Cylinders, the measures and weights of which are beyond the limits or the material of which is deficient, or which upon inspection show deformities or defects, are rejected without further test.

The finished cylinders are subjected to the following pressure tests:

Preliminary Test. A hydrostatic pressure of 1000 lbs. to the square inch is put on to round up the cylinders and to detect leaks. If, upon inspection after this test, the cylinders do not show any leak, local weakness, or any visible defect, they are subjected to the

Waterjacket Test, to ascertain their elasticity and permanent expansion. The test is made in the apparatus illustrated in Fig. 6.

A steel cylinder *B*, closed at one end and of sufficient size to receive the cylinder *A*, which is to be tested and having a cover of a design similar to *C*, in Fig. 6, is set in an upright position, and is

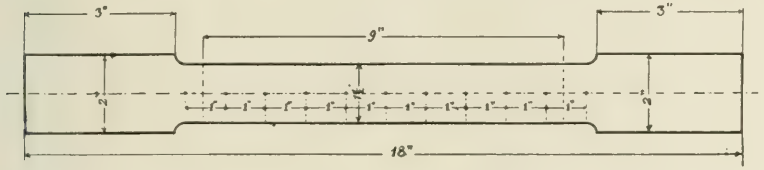


FIG. 5.—Testing Strength of Material.

connected with a gauge tube *D*, which in turn is provided with a scale divided in inches and tenths.

The apparatus is operated as follows:

Vessel *B* (called the jacket) is filled with water and cylinder *A*, also filled with water, is lowered into jacket *B*, care being taken that all the air is removed by means of a bent pipe from the cavity in the lower head of the cylinder. Cover *C* is put on, fastened with with suitable clamps and by screwing up the hand wheel *a*, the joint is made water tight between the rubber gasket *b* and the head of the cylinder. By opening valve *c*, water is admitted to *B*, which drives out all the air from the apparatus through the escape valve *d*. After closing *d* the water rises to the top of the gauge glass *D*, and sufficient water is allowed to run from the tube to remove all the air from the apparatus, whereupon valve *c* is closed. By manipulating valve *e*, the water column in *D* is adjusted to zero on the scale, and the apparatus is ready for the test.

Water under high pressure is now admitted through tube *E*,

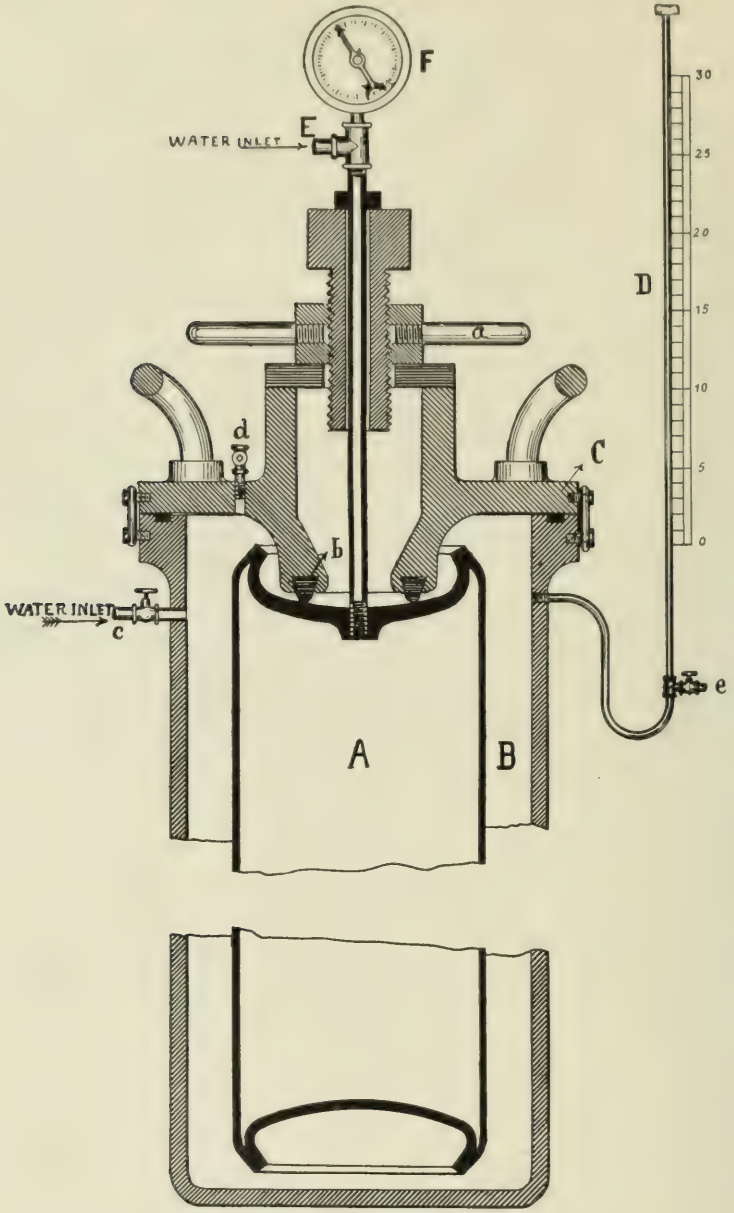


FIG. 6.—Apparatus for Making Waterjacket Test for Elasticity of Cylinders.

to the interior of cylinder *A*, the pressure being observed on the gauge *F*. With increasing pressure, cylinder *A* expands and drives an amount of water equal to the cubic expansion of the cylinder, into the gauge glass *D*, where its volume is read off by the scale. In a specific instance, the water column in tube *D* rose 11.1 ins. and this value represented the total cubical expansion of the cylinder under the prevailing pressure, which, in this instance, was 1000 lbs. to the square inch. Upon relieving the pressure, cylinder *A* contracted to near its former volume, the water column in *D* at the same time receding towards the zero mark. In the instance referred to the water receded to 0.35 in. on the scale, which represented the permanent expansion of the cylinder, caused by the application of 1000 lbs. pressure, and the quotient $\frac{0.35 \times 100}{11.1}$ 3.1 per cent indicated the permanent set, expressed in per cents of the total expansion.

If the permanent set is less than 10 per cent of the total expansion, the cylinder is considered safe for use and is accepted.

These are the tests prescribed by the regulations.

For the purpose of investigating how cylinders behave under other conditions, some additional experiments were made, which may be briefly mentioned.

1. Subjecting a cylinder to water jacket test, and ascertaining expansion and set at various pressures. The experiment was made in apparatus, Fig. 6, and the results are entered in the following table:

TABLE II

TEST OF A CYLINDER, 10 INCHES BY 7 FEET, 167 POUNDS 0.19 INCH WALLS. 7.2 PARTS ON THE SCALE = 100. cc.

Pressure, Pounds.	Exp. on Scale.	Set on Scale.	Set Per Cent of Exp.
400	4.4	0.1	2.3%
500	5.4	0.2	3.7
600	6.6	0.2	3.0
700	7.7	0.25	3.2
800	8.9	0.25	2.8
900	9.9	0.25	2.5
1000	11.1	0.35	3.1
1050	11.7	0.5	4.3
1100	12.5	0.8	6.4
1150	13.5	2.4	17.8% yield-point

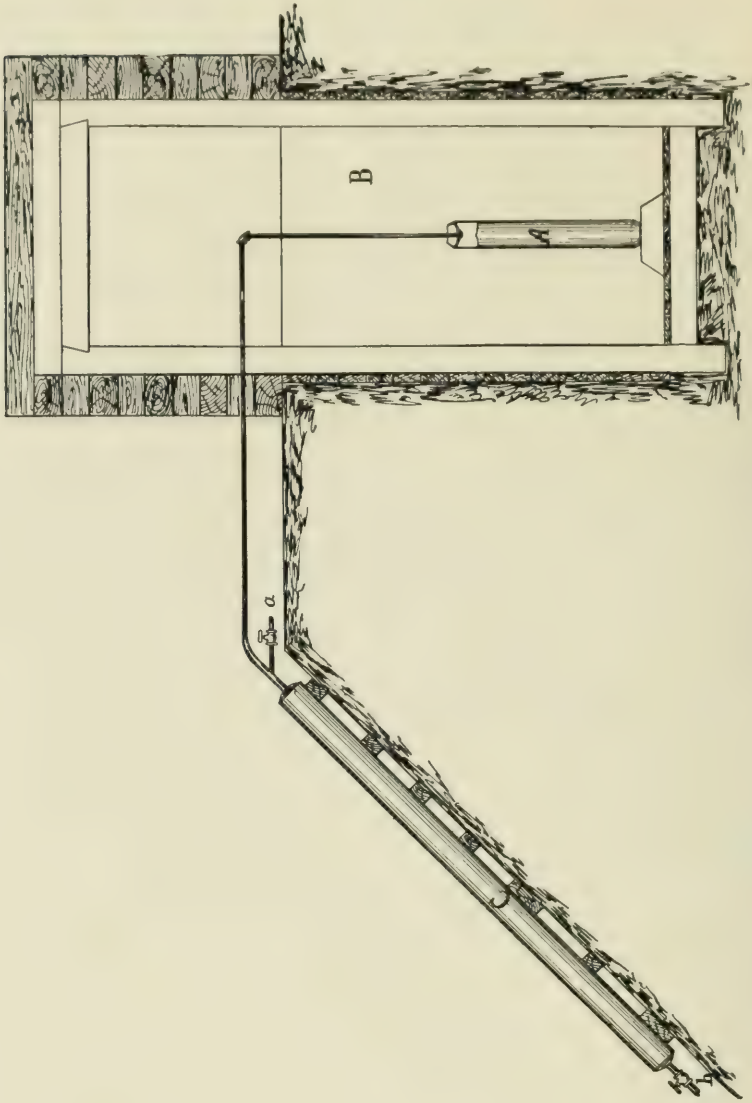


FIG. 7.—Arrangement for Subjecting a Cylinder to Hydropneumatic Pressure to Destruction.

2. Subjecting a cylinder to hydropneumatic pressure to destruction, done for the purpose of ascertaining whether cylinders made from certain materials will break up into flying fragments if they are exploded by gas pressure.

The arrangement of the experiment was as shown in Fig. 7. Cylinder *A* was set in pit *B*, which was dug into the ground and protected by heavy timbers.

On a nearby river bank, cylinder *C* (having five times the size of *A*) of heavy material and previously tested by internal hydrostatic pressure at 3000 lbs. to the square inch, was set at an angle of 45°, the top of this cylinder being connected with cylinder *C* by a $\frac{1}{2}$-in. extra strong pipe. Both cylinders were filled with air at 100 lbs. pressure by valve (*a*), whereupon valve (*a*) was closed. Subsequently water was admitted under high pressure by valve (*b*) into cylinder *C*, increasing gradually the air pressure and driving the air from cylinder *C* into cylinder *A* until explosion occurred.

FIG. 8.—Cylinder Exploded by Hydropneumatic Pressure.

An exploded cylinder is represented by Fig. 8. It was burst open, not sending out any fragments of metal in its destruction.

3. Subjecting a cylinder to drop test for the purpose of ascertaining whether cylinders of certain materials charged with compressed gas will break if they are dropped in a loaded condition from a platform, wagon or car, landing crosswise on another cylinder of the same description, lying on the ground.

The experiment was arranged as sketched in Fig. 9.

Cylinder *A* was put in a horizontal position into pit *B*, connected up to cylinder *C* and filled with air of the desired pressure.

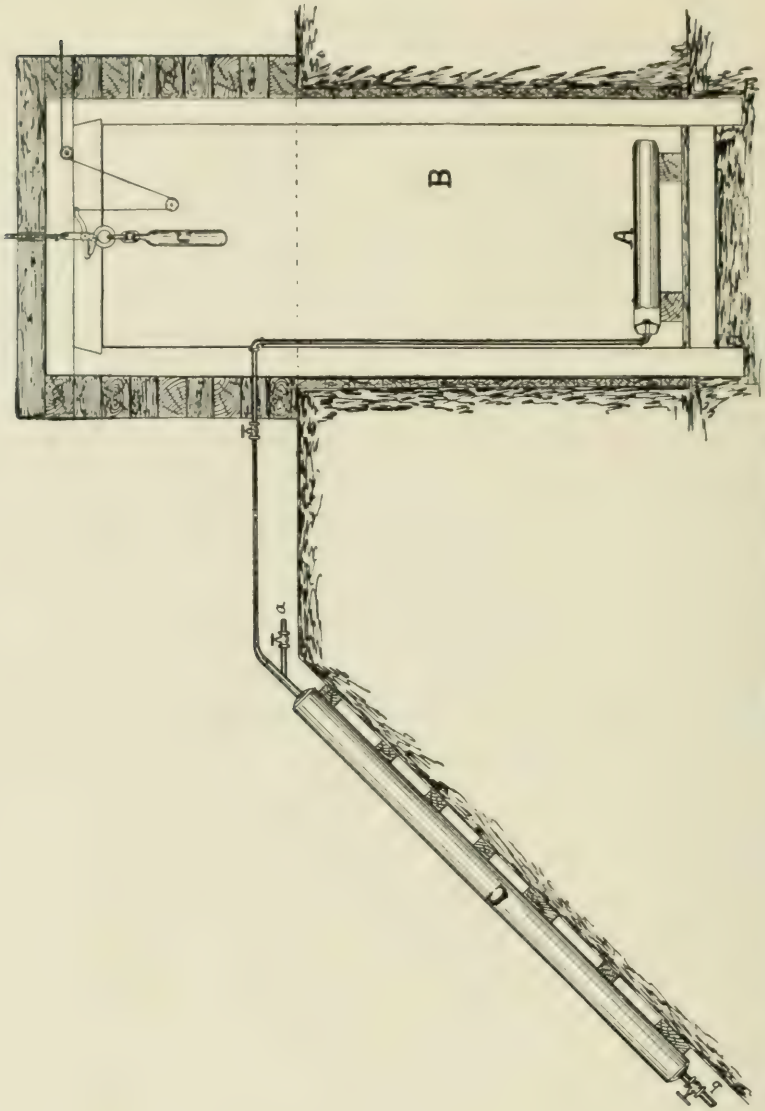


FIG. 9.—Drop Test of Cylinder.

A drop weight *G*, having the weight of a cylinder filled with ammonia, was suspended over the center of the cylinder and was dropped by releasing the lock. Two pictures, Fig. 10, show the indentations made by the weight. There being no fracture, the conclusion was drawn that the cylinders could have dropped from an equivalent height without causing a serious accident by explosion.

Pressure Gauges used for the Tests and Experiments. Attention is called to the unreliability of commercial pressure gauges under high pressures. Variations as high as 10 per cent were repeatedly found and it is necessary to make frequent comparisons with dead weight testing apparatus to ascertain the correctness of the instruments.

The apparatus used for controlling the gauges in the described experiments was of the design offered by the American Steam Gauge and Valve Manufacturing Co. of Boston, Mass., the accuracy of which was controlled by the United States Bureau of Standards and found to be correct within a fraction of one per cent.

FIG. 10.—Cylinders Subjected to Drop Tests.

THE MANUFACTURE AND TESTING OF CARBONIC ACID CYLINDERS

By JOHN C. MINOR, Jr.

Read at the Washington Meeting, Dec. 20, 1911

THE manufacture of liquefied carbonic acid was begun in this country about thirty years ago and has expanded to an industry of considerable magnitude. While its uses are of a varied nature, it is as the essential ingredient of carbonated beverages that carbonic acid has become an important article of commerce.

Until very recently there were no traffic regulations in this country covering the shipment of compressed gases, nor was there—unless perhaps in isolated cases—any effort on the part of manufacturers of such gases to procure gas cylinders of any distinctive type or particular quality. It was considered sufficient that the cylinders had—by a custom inherited from Germany—passed a hydrostatic test of 3700 lbs. per square inch.

In 1896 a British Parliamentary Committee made a lengthy investigation of questions relative to the safe transportation of compressed gases, and certain regulations were recommended in its report but did not become official. They mainly summarized what was in most respects the prevailing British practice, and when later they were largely embodied in the British Railroad transportation requirements but little difficulty was found in complying with them.

In Germany there were at that time Governmental regulations regarding the filling and testing of such cylinders, but only within comparatively recent years were these extended to cover the manufacture of the cylinders.

In this country the transportation of all dangerous or inflammable articles is now carried on under the regulations of the Bureau of Explosives of the American Railway Association as approved by the Interstate Commerce Commission. The Bureau, through its chief, Col. B. W. Dunn, first took up the matter of compressed and liquefied gases early in 1909.

There had already been some careful and extensive work done on this subject by Prof. R. T. Stewart, of the University of Pittsburgh. In his paper, "The Physical Properties of Carbonic Acid and the Conditions of its Economic Storage for Transportation," read in December, 1908, before the American Society of Mechanical Engineers—and from which the writer has freely drawn—are to be found in condensed and usable form valuable data relative to the physical properties of carbonic acid.

The National Tube Co. of Pittsburgh had also instituted a preliminary investigation of the subject and when, at the suggestion of the Bureau of Explosives the manufacturers of liquefied gases determined upon an investigation of the cylinder question, every facility was offered them by that company to make it complete, and to it is due the credit of much of the cylinder data here presented.

Before considering the cylinders themselves several facts regarding carbonic acid may be noted. This product may appear in transit either in liquid form, or as a vapor, or in both conditions, together. Its critical temperature is 88.4° F., above which it cannot exist in liquid form. At any temperature below this, all of the cylinder may be filled with the liquid gas or a part of it may be filled with the liquid and the remainder with the saturated vapor. Just as long as there is saturated vapor present, the pressure will be constant for a fixed temperature without reference to the proportion of liquid present, but when the cylinder becomes entirely filled with the liquid the pressure will no longer be constant for a fixed temperature.

It is obvious that the condition, whether gaseous, liquid, or both, that obtains below the critical temperature within the cylinder and the pressure thereby exerted on its walls is dependent on the relation existing between the total capacity of the cylinder and the amount of carbonic acid which it contains. This relation is expressed by Prof. Stewart in his table appended hereto, as the density, and represents the proportion of filling in pounds of carbonic acid per pound of water capacity; being for each condition tabulated, the combined densities of the liquid and its saturated vapor, and being equal in each case to their combined weights divided by the weight of their combined volumes of water at its maximum density. That is: a density of .75 would mean that a cylinder which could hold 100 lbs. of water had 75 lbs. of carbonic acid in it, or a cylinder with a water capacity of 80 lbs. contained 60 lbs. of carbonic acid.

DENSITY Water at 39.2°F = 1	Temperature in Degrees Fahrenheit								
	32°	40°	50°	60°	70°	80°	90°	100°	110°
.50	504	565	650	744	849	966	1095	1245	1395
.51	504	565	650	744	849	965	1100	1250	1405
.52	504	565	650	744	849	965	1100	1255	1415
.53	504	565	650	744	849	965	1100	1260	1425
.54	504	565	650	744	849	965	1105	1265	1440
.55	504	565	650	744	849	965	1105	1270	1450
.56	504	565	650	744	849	965	1105	1280	1465
.57	504	565	650	744	849	965	1110	1290	1475
.58	504	565	650	744	849	965	1110	1300	1490
.59	504	565	650	744	849	965	1115	1310	1505
.60	504	565	650	744	849	965	1115	1320	1520
.61	504	565	650	744	849	965	1120	1330	1540
.62	504	565	650	744	849	965	1130	1340	1560
.63	504	565	650	744	849	965	1140	1355	1580
.64	504	565	650	744	849	965	1150	1375	1605
.65	504	565	650	744	849	965	1160	1395	1630
.66	504	565	650	744	849	965	1175	1415	1660
.67	504	565	650	744	849	965 B	1190	1440	1690
.68	504	565	650	744	849	975	1205	1465	1725
.69	504	565	650	744	849	990	1230	1495	1765
.70	504	565	650	744	849	1005	1255	1530	1810
.71	504	565	650	744	849	1025	1285	1570	1855
.72	504	565	650	744	849	1050	1320	1610	1910
.73	504	565	650	744	849	1080	1360	1660	1970
.74	504	565	650	744	849	1110	1405	1720	2035
.75	504	565	650	744	849	1145	1460	1785	2110
.76	504	565	650	744	870	1190	1515	1850	2190
.77	504	565	650	744	910	1240	1575	1925	2275
.78	504	565	650	744	955	1295	1645	2005	2370
.79	504	565	650	744	1005	1355	1715	2090	2470
.80	504	565	650	744	1060	1425	1795	2185	2575
.81	504	565	650	750	1120	1500	1885	2290	2695
.82	504	565	650	800	1190	1585	1985	2405	2825
.83	504	565	650	860	1260	1675	2095	2530	2965
.84	504	565	650	935	1345	1780	2215	2665	3115
.85	504	565	650	1020	1445	1895	2345	2815	3285
.86	504	565	685	1110	1550	2020	2490	2980	3465
.87	504	565	765	1210	1665	2155	2650	3160	3665
.88	504	565	855	1325	1800	2310	2825	3360	3880
.89	504	565	960	1450	1950	2485	3020	3565	4110
.90	504	655	1080	1595	2120	2675	3235	3800	4355
.91	A 504	765	1215	1755	2305	2880	3470	4050	4625
.92	530	880	1360	1925	2505	3115	3720	4320	4910
.93	620	1005	1625	2120	2740	3375	3995	4610	
.94	725	1145	1715	2340	2990	3645	4285	4920	
.95	855	1320	1935	2590	3255	3935	4585		
.96	1010	1515	2175	2860	3545	4240	4910		
.97	1200	1740	2445	3150	3850	4565			
.98	1435	2005	2745	3480	4195	4915			
.99	1700	2305	3065	3825	4555				
1.00	2010	2635	3415	4200	4940				

Temperature in Degrees Fahrenheit

120°	130°	140°	150°	160°	170°	180°	190°	200°	212°
1550	1710	1870	2030	2185	2345	2505	2665	2825	3020
1565	1730	1895	2055	2220	2385	2550	2715	2880	3080
1580	1750	1915	2085	2255	2425	2595	2765	2930	3140
1600	1770	1940	2115	2290	2465	2640	2815	2990	3205
1615	1790	1970	2145	2325	2505	2685	2870	3050	3270
1630	1810	1995	2180	2365	2550	2735	2925	3110	3340
1650	1835	2025	2215	2405	2600	2790	2980	3175	3410
1670	1860	2055	2255	2450	2650	2845	3045	3245	3490
1690	1885	2090	2295	2495	2705	2905	3115	3320	3570
1710	1915	2125	2335	2545	2760	2970	3185	3395	3655
1735	1945	2160	2380	2595	2815	3035	3255	3475	3745
1760	1975	2200	2425	2645	2875	3100	3330	3555	3835
1785	2010	2240	2475	2700	2940	3170	3405	3640	3925
1815	2045	2285	2525	2760	3005	3240	3485	3725	4020
1845	2080	2330	2575	2820	3070	3315	3570	3815	4120
1875	2120	2375	2630	2885	3140	3395	3655	3910	4225
1910	2165	2430	2690	2950	3215	3480	3750	4010	4335
1950	2210	2485	2755	3025	3300	3570	3850	4120	4455
1995	2265	2545	2825	3105	3390	3670	3955	4235	4580
2040	2325	2615	2900	3190	3485	3775	4070	4355	4710
2095	2385	2685	2985	3280	3585	3885	4190	4485	4850
2150	2455	2760	3070	3375	3690	4000	4315	4620	5000
2215	2530	2845	3165	3480	3800	4125	4450	4765	
2290	2610	2940	3265	3595	3925	4260	4590	4915	
2365	2700	3040	3375	3715	4055	4400	4740		
2450	2790	3145	3495	3845	4195	4545	4895		
2535	2890	3255	3620	3980	4340	4700			
2635	3000	3380	3755	4120	4495	4865			
2740	3120	3520	3895	4275	4665				
2850	3245	3650	4050	4440	4840				
2975	3385	3800	4210	4615					
3110	3530	3960	4390	4800					
3255	3685	4130	4575	5000					
3410	3855	4315	4775						
3575	4040	4510	4985						
3760	4240	4720							
3960	4450	4950							
4175	4680								
4410	4935								
4655									
4915									

Reference to this table of Prof. Stewart will show for any given proportion of filling or density, the pressure exerted by carbonic acid within the cylinder for any given temperature and which it must under all conditions safely resist. These pressures are increased by about 60 lbs. per square inch for each per cent of air present. Manifestly, strength to resist pressure is only one feature of a properly designed cylinder and ability to withstand rough handling in transportation and to resist fragmentation on

FIG. 1.—Cupped Plates.

fracture are other important elements in the problem of producing a safe cylinder.

Carbonic acid gas cylinders are made in this country by three different processes.

In the plate process, a circular plate, of a thickness and diameter corresponding to the size of cylinder to be manufactured, is heated and punched into a half spherical cup. (Fig. 1.) This cup is then pushed through a series of round dies over an inside mandrel governing the inside diameter. (Fig. 2.)

In this manner, this cup is elongated and reduced in diameter and thickness of wall until the proper dimensions are obtained. The bottom of this cup has the thickness of the original plate, with

a slight reduction caused by the several heats through which it has passed, and in the last elongating operation it may be dished or flattened to enable the cylinder to stand upright. The elongated cup is now cut to length and the open end swaged between hammer dies into the shape of a bottle-neck.

After this operation the cylinder is annealed and heat treated as the case may be, and then finished up by threading the neck and testing in accordance with specifications.

In the spinning process, a hot-finished seamless tube with both ends open, is heated at one end and by a process of " spinning " the

FIG. 2.—Hot Draw Bench.

end of the tube is closed and welded in the center so as to form a homogeneous bottom in the tube.

The " spinning " process itself is very simple. The " spinning machine " is a type of lathe with a hollow spindle, so adapted that cylinders or tubes to be spun may be put into it and chucked, with the end which is to be worked extending outside of the chuck. This end having been heated, the tube is put into the lathe which is then rotated at from 1200 to 1400 revolutions per minute. At that speed, a tool is brought to bear against the rotating end of the tube. This tool, sweeping the end of the tube in a half circle, forces its sides to meet in the center, where the high heat, caused by the friction of the tool against the tube, produces a perfect weld in the center.

The bottom thus formed is then dished or flattened, or a loose ring may be shrunk around it to enable the cylinder to stand upright. The necked end is produced as already described under the plate process.

In the lap-weld process, now obsolete, a lap-weld tube of the proper dimensions is used and one end is necked down over a plug about 4 ins. in diameter by 1 in. thick. This plug is welded into the neck end of the cylinder, thus forming the head. The bottom is formed by welding a half spherical cup into the bottom end, with the concave side of the cup out, thus enabling the cylinder to stand on its bottom. The annealing, testing, etc., as above described, also applies to this cylinder.

In the plate process, cylinders from 3 ins. diameter up to 20 ins. diameter are made.

In the spinning process, cylinders from 1 in. diameter up to 6 ins. diameter are made.

In the lap-weld process, cylinders from 3 ins. diameter up to 8 ins. diameter have been made.

There are in use in this country for conveying carbonic acid several sizes of cylinders of both the seamless and lap-welded types, of which the larger part are the $5\frac{1}{2}$ ins. by 51 ins. and $5\frac{1}{2}$ ins. by 48 ins. lap-welded and the $8\frac{1}{2}$ ins. by 51 ins. seamless cylinders. The $5\frac{1}{2}$-in. cylinders are filled with 20 lbs. of gas giving a filling density of .66 for those of 48-in. lengths and of .57 for those 51 ins. long. The $8\frac{1}{2}$-in. cylinders are filled with 50 lbs. of gas giving a filling density of .57.

The present paper is devoted only to the subject of the seamless cylinders, as the tendency in high pressure work, i.e., 1000 lbs. and over, has been to develop that type in preference to the lap-welded cylinder, and the latter has been fully covered by Dr. Frerich's paper.

In the preparation of regulations to govern the transportation—and later, the manufacture—of cylinders it was necessary to assume a maximum temperature to which cylinders in transit might be exposed. In Germany the revised regulations set this at 104° F. but in this country it was fixed by the Bureau of Explosives at 130° F.

Reference to Prof. Stewart's table shows that with the fillings mentioned above and a temperature of 130°, the $5\frac{1}{2}$-in. by 48-in., cylinder would have a pressure of 2210 lbs. per square inch

while the pressure in the $5\frac{1}{2}$-in. by 51-in. and the $8\frac{1}{2}$-in. by 51-in. cylinders would be 1860 lbs.

The British standard as recommended by the Parliamentary Committee in 1896 is as follows:

Carbon. Not to exceed .25 per cent.

Iron. Not to be less than 99.00 per cent.

Elongation. On 8-in. bar from finished cylinder not to be less than 15 per cent.

Tensile Strength. Not to be less than 63,000 lbs. nor more than 74,000 lbs. All cylinders to be annealed before putting into service.

A large number of seamless cylinders of this character, known as the Linde cylinders, and used for compressed oxygen, have been made in this country under a slightly different specification, briefly as follows:

Carbon	Not to exceed 0.25 per cent.
Manganese	" " 0.60 "
Phosphorus	" " 0.04 "
Sulphur	" " 0.04 "
Silicon	" " 0.35 "
Elongation	Not less than 15 per cent.

Tensile strength. Not less than 62,000 nor more than 76,000 lbs.

All cylinders to be annealed, and to pass a hydrostatic sketch test of 3600 lbs. per square inch.

Representative cylinders to be submitted to a flattening test.

This, of course, is a mild, ductile steel and there had been a somewhat prevalent impression that a cylinder of such metal, if exploded from fire or other causes would not fragment, but merely open up and thus greatly reduce the chance of personal injury and, indeed, it has been toward obtaining such a cylinder, if possible, that recent efforts have been mainly directed. It was recognized, however, than the large carbonic acid cylinders must carry a load of 50 lbs. of gas; that a maximum temperature of 130° was assumed against 104° on the other side; that our freightage distances and rates were very considerable; and that in view of all this we could not consider a cylinder which like the English or Linde type would weigh, when empty, about 170 lbs.

In view of the absence of data concerning cylinders already in use in this country, samples were selected at random from various parts of the country. The experiments performed consisted of:

1. *Tensile Tests of Material Cut in Longitudinal Direction.* Data appended. (Table II.)

2. *Bending Tests of Samples Cut in Transverse Direction.* These were bent until fracture occurred and in all but a few instances the

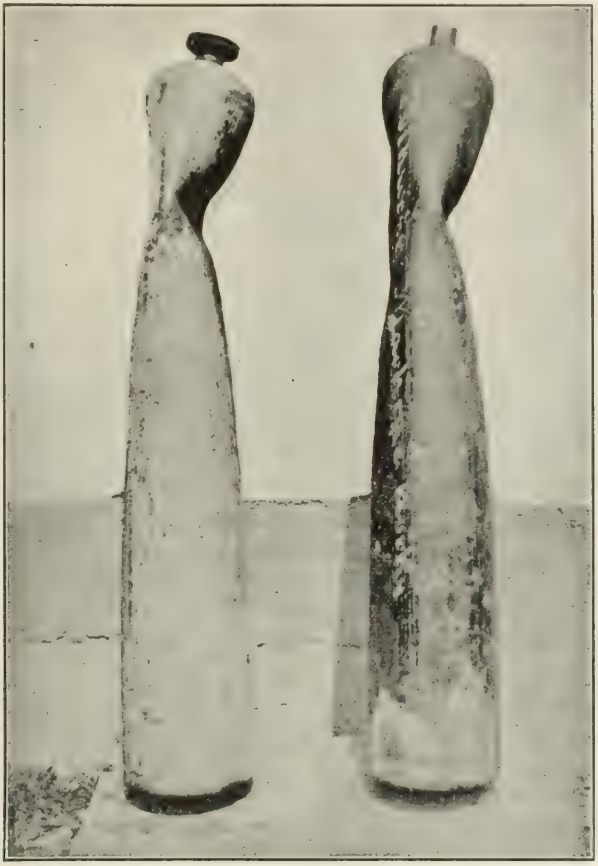


FIG. 3.—Transverse Tests.

bend was through an arc of 180° about a mandrel whose diameter was less than four times the thickness of the specimen.

3. *Transverse Tests of Whole Cylinders.* (Fig. 3.) Several representative cylinders were tested by placing them on two bars of iron, 1 in. wide and spaced 9 ins. on centers and applying a center load

through a piece of shafting $2\frac{1}{2}$ ins. in diameter. These tests showed that a very considerable amount of distortion was endured before even the poorest cracked. The low carbon cylinders did not crack at all.

4. *Chemical Analyses.* Data of these are appended.

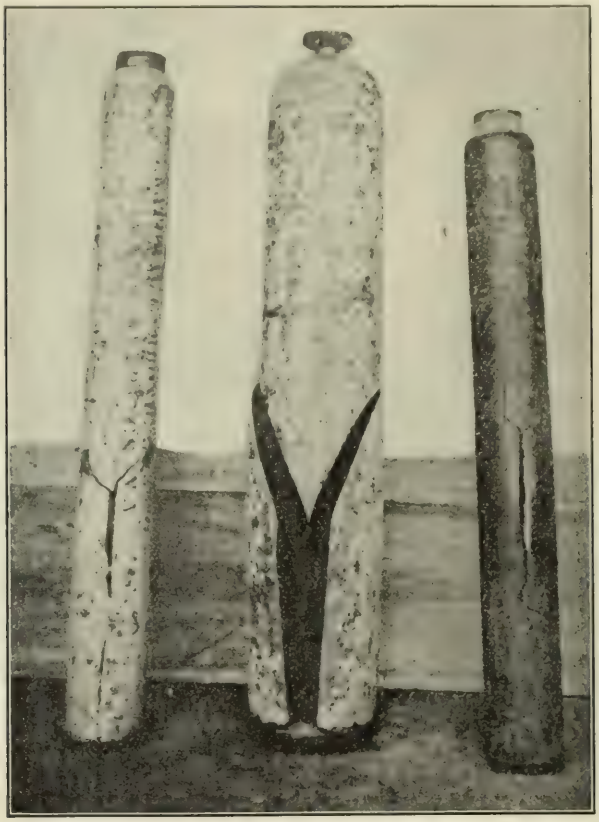


FIG. 4.—Hydraulic Tests.

5. *Hydraulic Bursting Tests.* (Fig. 4.) Water was forced into the cylinders until rupture occurred. Two small lap-welded cylinders ruptured along the weld, each at a pressure of 4400 lbs. One large seamless cylinder burst at 5600 lbs. The form of fracture seemed characteristic in all, as shown by the photographs.

6. *Fire Tests.* Cylinders were filled with their usual capacity of carbonic acid and placed in the open over a hot fire of oil-soaked wood. It took 8 to 12 minutes direct exposure to produce rupture.

Cyl. No. 1. Large seamless type. (Fig. 5.) Carbon .56. The bottom was blown off, the cylinder split in halves and a piece about 6 ins. by 8 ins. blown off near the shoulder.

FIG. 5.—Fire Test, Cylinder No. 1.

Cyl. No. 2. Small lap-welded type. Carbon .11. Ruptured along weld without fragmentation.

Cyl. No. 3. Large seamless type. Carbon .63. Bottom blew off but no other fracture.

Cyl. No. 4. (Fig. 6.) Large seamless type. Carbon .55. Bottom blew off. Remainder flattened out.

Cyl. No. 5. Large seamless type. Result like No. 4, except two pieces of shoulder flew off.

FIG. 6.—Fire Test, Cylinder No. 4.

7. *Expansion Tests.* Three cylinders were subjected to hydraulic pressure in a water jacket until sufficient pressure was applied to stress the material to its elastic limit. This was found to be about 4000 lbs. in each case.

TABLE II

PHYSICAL AND CHEMICAL TESTS ON CYLINDERS IN SERVICE

	t	d	E.L	ULT	%EL 8"	% RED AREA	C	P.	S.	MN.	Si.
Small Lapwelded Cylinders											
G	.300	5.50	38070	59040	20.4	57.9	.12	097	.063	.701	.018
H	.280	5.50	37970	57160	23.0	53.4	.10	.123	.070	.492	.010
I	.316	5.50	37970	57980	21.5	57.6	.12	.114	.088	.418	.007
J	.300	5.50	38920	56320	21.5	58.7	.10	.123	.096	.424	.019
X	.250	5.60	41340	59480	24.2	50.4	.10	.103	.067	.455	.012
Y	.278	5.60	38730	61020	23.0	52.6	.11	.110	.076	.455	.008
AA	.275	5.56	37670	60100	19.6	55.7	.11	.110	.073	.522	.009
AVERAGE	.285	5.55	38670	58730	21.9	57.0	.11	.111	.076	.495	.012

	t	d	E.L.	ULT.	%EL 8"	%RED AREA	C.	P.	S.	MN.	Si.
Large German Seamless											
Q	.280	8.56	61490	94340	2.0	42.9	.45	.049	.051	1.11	.160
R	.285	8.00	61160	76580	14.1	39.3	.14	.094	.056	1.18	.110
S	.260	8.05	70830	96960	15.8	49.6	.33	.061	.066	1.16	.175
T	.232	8.62	73080	87700	10.9	41.6	.14	.092	.059	.688	.110
U	.222	8.50	68560	95850	14.0	40.5	.19	.101	.063	.971	.248
AVERAGE	.256	8.35	66420	90280	14.9	42.8	.25	.079	.059	1.02	.160

	t	d	E.L	ULT.	%EL 8"	%RED AREA	C	P	S	MN.	Si
Large American Seamless OPEN HEARTH											
C	.220	8.78	58890	107100	13.5	28.1	.64	.035		.641	
E							.54	.058		.658	
L	.250	8.60	66300	111150	11.6	26.9	.50	.016	.033	.565	.143
M	.250	8.60	60570	102520	14.0	33.0	.42	.025	034	.960	.024
N	.270	8.54	60820	122830	12.0	27.8	.52	.092	.042	.651	.071
O	.240	8.55	72870	116920	10.8	21.4	.60	.039	.084	.707	.134
P	.225	8.66	89290	129870	6.3	24.6	.67	.019	.042	.578	.110
V	.230	8.70	65900	97210	16.2	34.6	.45	.030	.024	.737	.023
W	.248	8.62	64180	119900	11.2	19.6	.47	.039	.030	.744	.017
AVERAGE	.242	8.63	67350	113430	11.9	27.0	.53	.039	.044	.693	.075

	t	d	E.L.	ULT.	%EL 8"	%RED AREA	C	P	S	MN.	Si.
Large American Seamless BESSEMER											
B	.232	8.60	64160	88920	15.2	41.8	.21	.110		.756	
K	.230	8.55	71470	90100	13.8	41.4	.15	.107	.056	.755	.180
Z	.250	8.60	58710	93350	16.0	44.1	.15	.110	.066	.928	.196
AVERAGE	.237	8.58	64780	90790	15.0	42.4	.17	.109	.061	.813	.188

These tests were made on cylinders which had been in service for from three to seventeen years and were conducted at the laboratories of the Rensselaer Polytechnic Institute at Troy and in the field at Saratoga.

No one of the lap-welded cylinders shows in any feature a marked departure from the general average of the lot except Cyl. *G*, which has .701 manganese against an average of .495, a fact which does not appear to be reflected in any physical feature of the cylinder.

The high phosphorus in all of this group, averaging .111, is a marked characteristic and as a prejudicial hardener opens this type to criticism. Nevertheless, the broken specimens showed a fairly reasonable degree of ductility.

The German cylinders showed very different steel from that offered in this country for cylinders. They vary from .14 to .45 carbon, run high in silicon—from .110 to .248, and with one exception are very high in manganese, averaging 1.02. These high manganese cylinders, whether of German or American make, not only show satisfactory ductility but exhibit high values of ultimate reduction of the fractured section.

There was disclosed by these tests an irregularity of chemical contents and corresponding physical results which are not desirable in metal which it is possible to standardize, but it was felt that they justified the general observation that the cylinders might be considered safe for transportation under such pressures as would in no case produce stresses greater than three-quarters of the elastic limit. They also emphasized the desirability of ascertaining and prescribing the most suitable metal for this work.

Work was then directed along this line and the following specifications tentatively adopted. In view of the results subsequently obtained in the various tests briefly outlined below they were later incorporated, through the Bureau of Explosives, in the Regulations of the Interstate Commerce Commission, becoming effective October 1, 1911.

Specifications for Seamless Steel Carbonic Acid Gas Cylinders as Approved by the Bureau of Explosives, American Railway Association

Cylinders are to be made seamless, of steel of uniform quality, to comply in the present state of the art with the following specifications:

CHEMICAL ANALYSIS

Carbon is not to exceed..... .55 per cent.
Phosphorus is not to exceed..... .04 "
Sulphur is not to exceed..... .05 "

PHYSICAL TESTS

Elastic limit is not to be less than 50,000 lbs., nor more than 65,000 lbs. per square inch on specimen cut longitudinally from a representative finished cylinder after annealing.

Elongation is not to be less than 10 per cent on an 8-in. length of longitudinal test specimen cut from a representative finished cylinder after annealing.

FLATTENING TEST

For each lot of 200 a representative finished cylinder, after annealing, is to withstand, without cracking, flattening between rounded knife edges to a thickness of four times the thickness of the wall of the cylinder. The knife edges are to be of wedge shape, converging at an angle of 60°, the point being rounded off with a radius on one-half inch. If any one cylinder from any lot fails to pass this test, two others from the same lot will be selected, and these must pass it in order to have the lot accepted. If it should appear that failure in the test was due to improper annealing, the manufacturer has the privilege of re-annealing the lot and repeating the test.

One out of each 200 cylinders is to be subjected to the above chemical, physical and flattening tests.

ANNEALING

All cylinders after finishing are to be uniformly and properly annealed. Dirt and scale to be removed before painting.

HYDROSTATIC TEST

Every finished and annealed cylinder is to be subjected to hydrostatic test in a water jacket or other apparatus of approved form, whereby an interior pressure of not less than 3000 lbs. per square inch will be applied. The permanent expansion shall not exceed 5 per cent of the whole volumetric expansion at this pressure.

THICKNESS

The wall of cylinders of both $5\frac{1}{2}$ ins. and $8\frac{1}{2}$ ins. outside diameter is not to be less than .25 in. thick and this is to be verified on each cylinder before necking down.

WEIGHT

The standard $8\frac{1}{2}$-in. by 51-in. cylinder, without cap, shall weigh not less than 105 lbs. nor more than 115 lbs.

INSPECTION

The purchaser shall provide for inspection at the mills by a competent and disinterested authority, who shall be provided with a copy of the order containing all information relating thereto other than price. The Inspector shall keep complete records of the various melts from which the steel is taken for the manufacture of the cylinders. Chemical analyses of these melts must be supplied to him by the manufacturer, or if desired by the purchaser, he will procure samples from which other chemical analyses may be made. The heat number shall be stamped on these plates at the steel mill by the Inspector, and his stamp when placed on a completely finished cylinder, shall be taken as certifying that such cylinder comes within the above physical and chemical specifications.

The Inspector shall witness the hydrostatic and flattening tests of all cylinders and shall certify to the maker, the purchaser and the Chief Inspector of the Bureau of Explosives, No. 24 Park Place, New York City, the serial numbers of all cylinders which pass them successfully. He shall stamp his initials on such cylinder immediately beneath the serial number, and the initials of the owner shall be stamped on the flange or ring of the cylinder.

The Hydrostatic and Flattening tests shall be made by the manufacturer, but under the direction and supervision of the Inspector, or other representative of the purchaser.

GENERAL CONSTRUCTION

All plates from which cylinders are made shall be free from seams, cracks, laminations or any defects which may prove injurious to the finished cylinder.

The manufacture of the cylinders must be completed with the

best appliances and according to the best modern methods. All finished cylinders must show reasonably smooth and uniform surface finish, inspection of inside surface to be made before necking down; the threading of tap and of flange must be even and without checks, and the cylinders must show no defects of workmanship or material likely to result in any appreciable weakness of the finished cylinder. A close inspection of each completed cylinder shall be made to discover the existence of any defect before acceptance.

Extensive investigations were carried out by the National Tube Co. at McKeesport on cylinders made to these and to other specifications, involving explosion of the cylinders by air pressure, the destructive medium consisting on one part of water to twenty-five parts of air at atmospheric pressure.

Appended (Fig. 7) is a photograph of ten high carbon cylinders

FIG. 7.—Air Tests, High Carbon Cylinders.

thus exploded. These were from a lot closely approximating the above specifications.

They average on the unannealed cylinders as follows:

Carbon	.41
Phosphorus	.021
Sulphur	.030
Manganese	.63
Elastic limit	52,000 to 55,000 lbs.
Tensile strength	95,000 to 100,000 lbs.
Elongation	12% to 14%
Reduction of area	16% to 22%
Weight	95 lbs.

The average yield point of six cylinders before annealing was 3400 lbs.—after annealing 2900 lbs. Four cylinders, Nos. 7, 8, 9, 10, were not annealed. They burst at pressures from 5500 to 5800 lbs. per square inch. The others were annealed to temperatures

varying from 1440° to 1800° F. and burst at pressures of from 5050 to 5900 lbs. per square inch. The fragmentation was poor and showed no appreciable difference between the annealed and the unannealed cylinder.

In comparison with these results very gratifying results had been obtained at McKeesport on exploding with the same air mixture the low carbon Linde cylinders and especially some cylinders made of chrome vanadium steel. Photographs of both are appended.

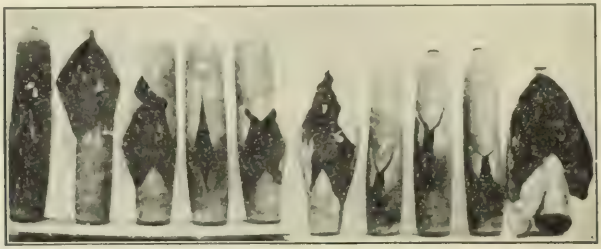


FIG. 8.—Air Tests, Linde Cylinders.

The Linde cylinders shown (Fig. 8) averaged as follows:

Silicon	.192
Sulphur	.016
Phosphorus	.015
Manganese	.50
Carbon	.23
Elastic limit	36,000 lbs.
Tensile strength	65,000 lbs.
Elongation in 8 ins.	27%
Reduction of area	50%

All were annealed to 1590° F. Seven of the ten cylinders had no permanent set at 3300 lbs. pressure. Five yielded at 3600 lbs. All burst at pressures from 6550 lbs. to 7000 lbs. and excepting one, which broke in two pieces, there was no fragmentation, the cylinders merely opening up.

The first lot of vanadium cylinders was made up with a $\frac{3}{16}$ in. wall and the weight averaged 77 lbs. against 95 lbs. for the old high carbon cylinders. The cylinders averaged as follows:

Carbon	.20
Phosphorus	.049
Manganese	.60
Silicon	.031
Chrome	1.05
Vanadium	.15
Elastic limit	63,500 to 68,800 lbs.
Tensile strength	74,000 to 93,000 lbs.
Elongation	8.25 to 16.5%
Reduction of area	41.8 to 50.4%

It should be noted that this test was taken from one of the untreated cylinders. This treatment comprised annealing to

FIG. 9.—Air Tests, Vanadium Cylinders.

1500°, tempering and reannealing to about 1000°, and produced quite uniform results. One cylinder which before treatment showed 15 per cent permanent set at 3500 lbs., showed after treatment none at 4000 lbs. and only yielded at 6250 lbs. The yield points varied from 5500 lbs. to 6650 lbs. and the bursting pressures from 6200 lbs. to 7100 lbs. per square inch. One cylinder broke in two pieces but the others stayed whole.

Another lot of vanadium cylinders (Fig. 9) was made exactly like the first except that the wall was made $\frac{1}{4}$ in. thick, bringing the weight up to 105 lbs. Before treatment all showed less than 5 per cent permanent set at 3500 lbs. pressure. One cylinder was not treated. It had 8 per cent permanent set at 4200 lbs. and burst at 6350 lbs. pressure. Two were annealed but not tempered.

One burst at 5400 lbs. and the other at 6000 lbs. Seven were annealed tempered, and reannealed, and burst at pressures varying from 6450 to 8500 lbs. The cylinder which had no treatment burst in two pieces but all the others simply opened up a longitudinal split and stayed whole.

The photographs show clearly the remarkable results obtained on exploding the vanadium cylinders with air, in comparison with other cylinders burst by the same process. It was, however, difficult to understand why the first lot mentioned, supposed to represent improvement over existing conditions, should have shattered worse

FIG. 10.—Fire Tests.

than did the type of cylinders in service when the latter were burst with carbonic acid over a fire.

Therefore three cylinders were taken: (Fig. 10) One of those made up to the new specifications, *N*, a Linde low carbon cylinder, *L*, and a vanadium cylinder, *V*. Each was filled with carbonic acid to a density of .57 and burst over an open fire at Saratoga. The photograph shows the result. The new high carbon cylinder, as usual with this type, had its bottom blown off, the remainder opening out in one piece. The vanadium cylinder opened up in about the same fashion and at least one good-sized piece flew off. The Linde cylinder blew into at least three pieces, only two-thirds of it being found after the explosion.

Another cylinder, No. 1 B, made to the new specifications, was

also blown up over fire with very similar results. Its composition was:

Carbon	.43
Phosphorus	.010
Manganese	.625

Another test was of a German cylinder, No. 1 A, about four years old, which on explosion broke in two pieces. Its composition was:

Carbon	.43
Phosphorus	.044
Sulphur	.046
Manganese	1.11
Silicon	.204

It will be observed that these fire tests gave results differing considerably from those obtained at McKeesport with the mixture of air and water and they were therefore continued at McKeesport, being preceded by several air tests.

Two cylinders made to the new specifications were exploded with air. One burst at 5500, the other 5900 lbs. pressure; no pieces flying and in each case showing two vertical cracks joined by a longitudinal one. A light weight vanadium cylinder opened up one short crack at 5300 lbs., and a Linde cylinder, at 7100 lbs., opened up a longitudinal crack extending at each end in two oblique directions.

The fire tests at McKeesport were made on cylinders R_4, R_6, R_7, and R_8 of the following composition:

Carbon	.41
Sulphur	.030
Phosphorus	.021
Manganese	.63

Also on Cylinder H, of the composition:

Carbon	.59
Sulphur	.031
Phosphorus	.020
Manganese	.69

These were all unannealed. Both types on explosion gave about

the same result and for some reason, appreciably different from that obtained at Saratoga in the fire tests heretofore mentioned. The method of applying the heat at McKeesport was such as to require from one-half hour to an hour to produce explosion whereas at Saratoga it took about ten minutes.

It had, therefore, been demonstrated by these tests, that no type of seamless cylinder yet available could withstand explosion from heat without fragmentation and that the new specifications

FIG. 11.—Tests on Order No. 6210.

FIG. 12.—Tests on Order No. 5623.

would furnish a satisfactory cylinder and they were therefore formally adopted.

In comparison with the varied results obtained in this investigation, it is of interest to note some of those in the tests of the first two lots made to order after the new specifications became official.

Test cylinders (Fig. 11) from order No. 6210 averaged:

Carbon	.45
Phosphorus	.019
Sulphur	.034
Elastic limit	54,700 lbs.
Tensile strength	84,600 lbs.
Elongation	18%
Weight	112 lbs.

Cylinder B_3 burst under air at 5600 lbs. and B_4 at 5000 lbs. Neither had any permanent set at 3000 lbs.

Test cylinders (Fig. 12) from order No. 5623 averaged:

Carbon	.45
Phosphorus	.017
Sulphur	.034
Elastic limit	55,700 lbs.
Tensile strength	90,900 lbs.
Elongation	15.5%

Cylinder B_1 burst under air at 5200 lbs., B_2 at 5650 lbs. and B_3 at 5600 lbs.

It will therefore be seen that on the whole there is reason for the belief that the new specifications mark a decided advance in the making of carbonic acid cylinders.

Both the new specifications and the Interstate Commerce regulations require a hydrostatic stretch test and the latter provide for its repetition every five years at a pressure not less than one and a quarter times the interior pressure that would result from heating the cylinder in its maximum charged condition to a temperature of 130°. A cylinder must be condemned if the permanent expansion exceeds 5 per cent of the total expansion.

Two methods may be used to conduct such tests with the required accuracy. In the water jacket method the cylinder to be tested is filled with water and submerged in a large tube or jacket through whose removable, but water-tight cover passes the pipe connecting the cylinder with the high pressure pump. The jacket is provided with a graduated glass tube like a gauge glass, to act as an expansion indicator, and is completely filled with water, after which the level in the glass tube is noted. The test pressure is then applied to the cylinder and the levels noted during and after the application, the water in the jacket being forced into the glass tube as the cylinder expands and receding to its former level after removal of pressure if there has been no permanent expansion. The other method (Fig. 13) involves the use of the Sturke-Watson-Stillman Testing machine and dispenses with a water-jacket. This machine consists essentially of a screw displacement piston which forces enough water into an already filled cylinder to produce the desired pressure.

Attached to the pump cylinder are two graduated glass tubes,

one serving as the expansion indicator, the other, back of the stuffing-box, as the leaking indicator. The exact delivery of the pump per turn of screw is known and provision made for registering each turn or fraction thereof.

Assuming the cylinder under test to be full of water and all con-

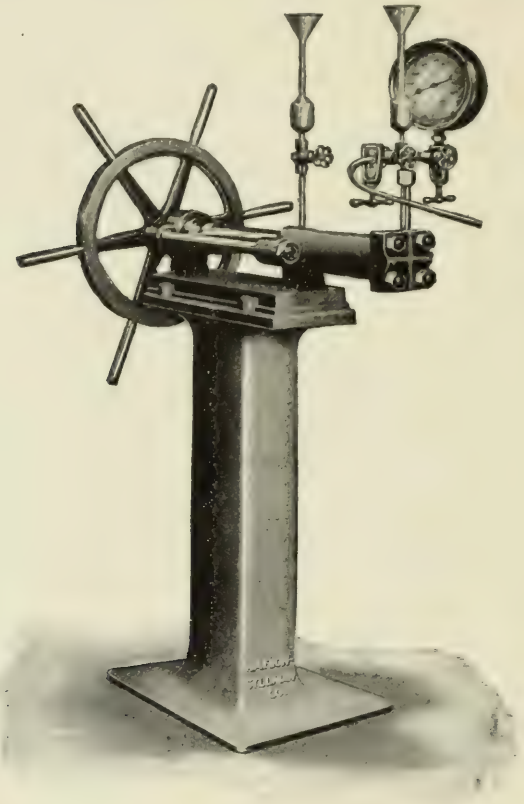


FIG. 13.—Sturke-Watson-Stillman Test Machine.

nections between it and the pump free of air, a reading is made of both indicators and the position of the piston accurately noted on the graduated scale provided for that purpose. The expansion indicator is then closed off with a valve, and the hand wheel turned until the desired pressure is attained, after which the piston is care-

fully returned to exactly its original position and the valve to the expansion indicator reopened. It is plain that if the cylinder suffered any permanent expansion its water-containing capacity must have been increased. The extent of this is measured by noting the new level—if such there be—in the expansion indicator after opening the valve.

In calculating the total expansion, proper allowance must be made for the compressibility of the water in both pump and cylinder and for the volume displaced as indicated on the graduated scale.

This method requires more care than the water-jacket method, but when properly conducted is more expeditious and avoids not only the discomforts attendant upon the raising of cylinders from immersion in water but also the necessity of any lifting whatsoever.

REPORT OF THE COMMITTEE OF CHEMICAL ENGINEERING EDUCATON

Read at the Chicago Meeting, June 21, 1911

The Committee on Chemical Engineering Education was created at the Pittsburgh meeting, December, 1908, and under the leadership of its able chairman, now our worthy President, has done a great deal of valuable work since that time. It has conducted a great deal of correspondence, compared the existing courses of study for chemical engineering students in several of the best American and European schools, and made two lengthy reports, one in June, 1910, at the Niagara Falls meeting and one in December, 1910, at the New York meeting. Both of these reports led to animated and instructive discussions, to the preparation and presentation in December last of the valuable papers of Dr. F. W. Atkinson and Professor M. C. Whitaker, and to the sending out of a circular letter with a series of queries to be answered by the membership of the Institute. Unfortunately, the election of Dr. Frerichs to the Presidency of the Institute made it necessary for him to relinquish the chairmanship of the Committee, and in reconstructing the Committee, a chairman was selected who has not had the opportunity to make the recent exhaustive study of the subject that Dr. Frerichs has made and must therefore apologize to the Institute for his inability to cover the ground in the thorough way in which the former chairman would certainly have done. However, we fortunately have our President in our midst and can count upon his participation in the discussion and his counsel in arriving at a judicious conclusion to the same, and we have upon the committee several members who have already made valuable contributions to the study of the problem, and who will further aid us in arriving at a solution worthy of the Institute.

To review briefly the work which has been done by the Committee and to note the results thus far achieved, we find in the

Bulletin of the Institute, issued in August, 1910, the text of a circular letter sent out by Dr. Frerichs as chairman under date of February 4, 1910, which contained as a basis of discussion a synopsis of the course in Chemical Engineering of a typical American University, and seven questions designed to elicit an expression of opinion as to what should be considered the proper course for a would-be chemical engineer. Of the replies received to the circular letter, four are embodied in the report made at the meeting of the Institute in June, 1910, viz., those of Messrs. McKenna, Wiechmann, Veillon and Booth. These are given consideration in the report of the Committee which follows, and certain of the views and conclusions of the writers indorsed and farther elaborated. The oral discussion at the Niagara Falls meeting was participated in by Messrs. Olsen, Baker and McKenna.

Attention is particularly drawn to the valuable list of desirable subjects for Post-Graduate study in a chemical engineering course, given at length on pp. 30 and 31 of the Bulletin, to which reference will be made again.

At the meeting held in New York in December, 1910, the subject of Chemical Engineering Education received a large amount of attention, the first session of the meeting being specially set apart for its consideration and discussion. The committee reported that additional communications on the subject had been received by them, mentioning those of Dr. Zwingenberger, Professor Horace G. Byers, Dr. Wm. D. Richardson and Dr. Wm. M. Grosvenor, the last-mentioned communication being read in full by the Committee in connection with its report. However, without wishing to appear invidious, the most important feature of the first session was the presentation of the two carefully prepared papers of Dr. F. W. Atkinson and Professor M. C. Whitaker, the one on "The Development of the Chemist as an Engineer," and the other on "The Training of Chemical Engineers." Each of these papers, which is published in full in the Bulletin of December, 1910, was concluded by a series of questions designed to elicit an expression of opinion from members of the Institute. These questions, which cover pretty fully the ground gone over in the two papers, were then printed and made the subject-matter for Circular No. 2, of the Committee on Chemical Engineering Education, which has been sent by our Secretary to every member of the Institute as well as to a number of prominent educators

in scientific schools and some men directly connected with important chemical industries.

With the answers that have come in reply to their circular letter and the previous expressions of opinion, to which reference has been made, we have all told the views of thirty-seven men before us—not an overwhelming expression, it is true, but enough to furnish us with material upon which to build conclusions and perhaps arrive at some definite expression of opinion upon the main points at issue.

These replies have been tabulated so as to enable one to see how each of the nineteen questions has been received and to allow us to arrive at some consensus of opinion upon most of them. Most of this tabulation was done in a very careful and painstaking way by the former Chairman of the Committee, Dr. Frerichs, and we have but transferred to his sheets the answers of a few whose replies came in late.

As it is obviously impossible for the Committee to present *in extenso* the replies and comment on the nineteen questions, contained in even so moderate a list of letters, we will take up first the views on question 2: " Is the prevailing system of education adequate to produce the chemical and engineering talent needed in the industry?" Of 28 specific answers to this question, 8 gave a qualified approval to present methods, and 20 a more or less emphatic " no." In addition to this showing, we have the letters published in the August and December Bulletins which reply to Dr. Frerichs' somewhat similar question, when, having given in full the four-year course of a typical American university, he asked, " Is, in your opinion, a chemist having completed a four-year course as offered at this university and possessing the degree of B.S. satisfactorily equipped to enter practical work?" The five answers to this question in the published letters were all " no."

It may be assumed that under the " prevailing system of education " was meant in the minds of those who replied a four-year course of the typical kind given by Dr. Frerichs in his first report. This is in fact stated by several. Professor C. F. Mabery, of the Case School of Applied Science, Cleveland, says in his answer to this question " needs a course of five years," and later he states what a fifth year should cover. It may be remarked incidentally that several of the technical schools have already made the course in Chemical Engineering a five-year course, as the Massachusetts

Institute of Technology and the Brooklyn Polytechnic Institute, but relatively recently.

If we turn now to question 8, "Of what should the course in applied or technical chemistry consist? Specify the subjects to be taken and the proficiency to be acquired in each." If we could have a complete answer to this question, the entire problem would be solved. Unfortunately we do not have such an answer. More than half of those replying to the circular declined to answer this question, and many of the answers given were quite indefinite and made no attempt to be complete.

Several of the replies, however, show such positive convictions as to what should or should not be taught that the Committee feel justified in quoting two of these expressions in full. The first is from a teacher, but one who has had exceptional opportunity to study manufacturing chemical processes by actual inspection in the works, and the other is from one of our younger members, who is the manager of a successful chemical plant and has had a wide range of experience.

"In most chemical engineering courses students spend entirely too much of their valuable time in college in playing with 'chemical practice.' The college is no place to teach a man the practice; it is a place to train him to think scientifically, and to handle the instruments of scientific investigation and make use of their results.

"Practice should be learned only in the works—by being employed or by systematic visits. A man can learn more of practice in four months in the works than the university can teach him in four years, and learn it better. Accepting that, use the time in the university to teach him *what he cannot acquire outside;* to do anything else is to waste his time."—Jos. W. Richards, Bethlehem, Pa.

"No chemical engineer can be a specialist in all or even many branches of the industry. Schools should equip men to think independently, thinking to be based on a broad general scientific knowledge. Most graduates have poor preparation in physics, mechanics, and engineering branches.

"The student who is going to make a truly meritorious and successful career in chemical engineering will get his broad training in fundamentals from the college theorists, and coincidently his practical ideas from *independent* and absorbed pursuit of the applications by study of the current journals, visits to every avialable factory, talks with practical men of every line of industry he can

connect up with. In my humble opinion, based on contact with both engineering and chemical industries and with college instructors, I regard it absolutely beyond reason to expect up-to-date, virile, practical instruction in the applications of theory to factory work, from those equipped to teach theory, and in my experience, it is the attempted *practical* teaching that the graduate must unlearn after he gets into practical work. No real success can follow without a broad grasp of physical laws of every kind taught in physics and engineering.

" If a chemical engineering graduate is to command and direct the work of chemists, laborers and mechanics, he must be able to see farther than they can, have full confidence in his grasp of physical laws, and above all he must have it in him to make a leader, else no amount of learning will avail."—Thomas Griswold, Jr., Midland, Mich.

Turning now to the equally important question No. 19, of the Circular No. 2, we are asked, " What in your opinion is the main cause of the failure of the present courses in chemical engineering to produce men who are prepared in the best possible way for practical work in the manufacturing establishments of the United States? "

This question assumes that the present courses, considered broadly, are failures from the point of view stated. Several of those answering this question do not concede this to have been the case. Because it presents this view so well, the committee will quote the language of an experienced educator, who is the head of a chemical engineering course in one of the most prominent technical schools of the country.

Professor Henry P. Talbot, of the Massachusetts Institute of Technology, says: " I should not admit that all are failures. Some lack all engineering features and contain what some might call academic instruction in chemistry, mathematics, and mechanics, without any real correlation.

" It seems to me that those charged with the education and training of the chemical engineer are confronted with an exceptionally difficult problem just now. It is a composite profession and in a very unformed state as yet. To an even larger extent than is the case with the older engineering professions; the scientific and technical progress has outrun the ability of the educational forces to keep pace with the increased demands, and I must confess that I feel that there is a rather unreasonable impatience in some quarters. An educational experiment which fundamentally affects the first year of a professional course requires about seven years for its comple-

tion, since three years after graduation is a minimum time in which to judge of results. Some of the best of our chemical engineering courses have not been in operation, in their modern form, as long as that.

" This is *not* equivalent to saying that they cannot or ought not to be improved, but I do not think that they have yet been fairly tested.

" To give fundamental instruction in fundamental chemical and engineering subjects demands the whole of four college years. This leaves little or no time for *applications*, and this apparently is our weak point. As compared with the civil or electrical engineer, or mechanical engineer, the chemical engineer at graduation is at a disadvantage, for he has not had any practice at his profession, which is really the *combination* and *practical application* of the *two* branches of his training. The remedies seem to be (*a*) an extra year, which is costly, but may be necessary, (*b*) required summer work. In either case, something must be provided on which he can practice. While I believe that the industries could help us a great deal, and benefit themselves by offering opportunities for summer employment, it is not now probable that they will do so to an extent which will remedy our alleged defects. The other alternative seems to be the erection of laboratories which imitate, so far as may be, the conditions of a manufacturing plant, and I am inclined to favor development of such laboratories as far as resources permit, but there are serious questions still to be answered, both with respect to details and to available time, which will retard progress for a time yet. I am not clear as to the development of the *business* aspects (beyond a knowledge of accounting)."

Still more pointed in answer to question 19 are the remarks of one of our members, who has followed an earlier teaching career by years devoted to chemical manufacturing. The Committee will quote from the reply to the Circular No. 2 sent by Dr. Launcelot W. Andrews, of Davenport, Iowa.

" 19. There appear to me to be two chief reasons for the shortcomings of the courses in 'Applied Chemistry.' One of these is general and is a fault of our entire educational system, the other is specific.

" The first lies in the fact that it is our educational practice to help the student far too much, to treat him as a recipient rather than an agent. His resourcefulness is not stimulated, his initiative is not developed.

" The second consists therein, that his practical (that is, laboratory) experience in chemistry is confined to reactions carried out on a very small scale and with apparatus to correspond. His thinking

is in terms of test-tubes and borax-beads. If you speak to him of filtration, it means to him a 3-inch disk of filter paper. He is unfamiliar with the tools he will have to work with, filter-presses, distillation columns, large mills, tank reactions, and with all the other aspects which chemical work has in the mind of the manufacturer. It is this ignorance of the tools of his trade that is the most serious obstacle he must overcome.

"The remedy is to be found in the equipment of laboratories with factory types of apparatus and in the institution of courses of study of such apparatus, determinations of their efficiency under various conditions, etc.

"In such study may easily be found a rich field for *research work*, which will tax the student's native resources to the limit, and will at the same time make him at home with his tools. Here is my pratial answer to questions 8 and 9. There is much in these views in common with those advanced by Professor Whitaker, but with an important difference. Dr. Whitaker disclaims the intention to give the chemical engineering student instruction in special industries, while at the same time he advocates the erection of a model gas-plant, or some other practical and complete plant, for instructional purpose. It is in the nature of the case that such a plant must be a mere imitation of the real thing, and I seriously doubt its value for the intended purpose. The same amount of time and money would probably bring in a much larger return if devoted to the separate study of those chemical manufacturing operations and appliances which constitute the elements or operative units out of which nearly every chemical factory is built up."

We think that the thought expressed in the last sentence of Dr. Andrews' remarks will bear study and developing.

Chemical manufacturing operations and appliances ought to be studied in both a descriptive and a practical way. Consider for a moment the variety of mixtures that have to be dealt with and from which values have to be extracted or created The methods of extraction and separation in wet and dry ways, purification, and modification whereby the product acquires valuable properties, can give rise to innumerable practical problems to be given to be worked out by the would-be chemical engineer. The economical handling of large quantities of materials, both end-products and lesser valuable side-products, should be studied in concrete examples as far as possible.

The former Chairman of the Committee, Dr. Frerichs, has given on pp. 30 and 31, of the Bulletin of August, 1910, a list of such lines of practical study that is very suggestive and shows some of the things that ought to go into a course for chemical engineers.

Then there are a few books, some in German and some in English, which take up for comparative study the appliances and apparatus of manufacturing chemical works. We may mention Parnicke's "Maschinelle Hilfsmittel der Chemischen Technick," Rauter's "Die Betriebsmittel der Chemischen Technik" and Oscar Nagel's "Mechanical Appliances of the Chemical and Metallurgical Industries."

The study in the classroom and in the technical-school laboratories of working models of factory apparatus and the designing of modifications and special forms for varying conditions under an instructor who has had factory acquaintance ought to help materially in developing independence of thought on the part of an intelligent student.

Just as the making of preparations, both simple and more complex, is now considered a proper and necessary part of the work of the inorganic and the organic chemical laboratories, so the making of preparations on a small factory scale, using factory appliances and factory methods, and above all reckoning the cost of materials, time and labor, ought to be systematically practiced as a proper training for chemical engineering students. Our German brethren have published books covering this line of instruction also. I have a recent one which I found quite suggestive and of the type I have had in mind in referring to such exercises. It is called "Chemisches Prakticum, Präparative und Fabrikatorische Uebungen" by A. Wolfrum, and is accompanied by an Atlas on "Die Apparate der Chemischen Technik und des Laboratoriums, sowie die Einrichtung Vollständiger Betriebe," with many figures and tables.

However, the Committee feel that it is not their province to go too much into detail concerning courses but to present to the Institute what has resulted from the issuing of the Circular No. 2 to the Institute membership and would leave it to the Institute to determine what, if any, steps should be taken to give expression to our views in some formal or official way to those interested in chemical engineering education.

(Signed) SAML. P. SADTLER,
Chairman Committee.

CIRCULAR LETTER No. 2

Committee on Chemical Engineering Education

The discussion at the third Annual Meeting of the Institute on the report of the Committee on Chemical Engineering Education developed the fact that there is widespread dissatisfaction with the courses given in American Universities and Technical Schools in Chemical Engineering, and that there has been no precise statement of the defects of such courses, nor is there any agreement on what an ideal course should embody.

An attempt is being made by the American Institute of Chemical Engineers to formulate the opinions of the chemical profession on these questions. For this purpose a resolution was passed at the third annual meeting of the Institute to submit to its entire membership, as well as to others interested in the subject, a list of questions submitted by Dr. Fred. W. Atkinson, President of the Polytechnic Institute of Brooklyn, N. Y., and Professor M. C. Whitaker of Columbia University. The papers read by these educators as well as the report of the Committee on Chemical Engineering Education and a synopsis of the discussion at the meeting, are submitted herewith as the December Bulletin of the Institute. The report of the Committee on Chemical Engineering Education presented at the Niagara Falls meeting has been published in the August Bulletin of the Institute as well as in the October number of *The Journal of Industrial and Engineering Chemistry*.

You are earnestly requested to give your opinion on the questions submitted by filling out and forwarding to the Secretary the blank submitted herewith.

J. C. Olsen,
Secretary.

Committee on Chemical Engineering Education,
Samuel P. Sadtler, *Chairman.*
Wm. M. Booth, M. C. Whitaker,
A. A. L. Veillon, F. G. Wiechmann.

QUESTIONS ON CHEMICAL ENGINEERING EDUCATION

1.* Is the definition of chemical engineer and the outline of his requirements substantially correct?

Ans. Yes, 17. No, 5.

2.* Is the prevailing system of education adequate to produce the chemical and engineering talent needed in the industry?

Ans. Yes, 8. No, 21.

3.* Does the present method of training chemical engineers produce men comparable in their respective qualifications with civil, mining, and mechanical engineers?

Ans. Yes, 8. No, 20.

4.* Do factory managers find our graduates qualified to assist in building up and developing the business, or are they simply "prospects" who must be "educated" at the expense, in time and money, of the industry employing them?

Ans. Yes, 2. No, 27.

5. If a negative answer is given to Question 4, is it possible for the technical school to give training which can take the place of the factory education?

Ans. Yes, 12. No, 18.

6. Of what educational value are excursions through chemical plants?

Ans. Of great value, 25. Of slight value, 8.

7.* Are the men who receive their experience in the application of the fundamentals in the works where they are employed narrow in their perspective and limited in resourcefulness?

Ans. Yes, 23. No, 9.

8.† Of what should the course in applied or technical chemistry consist? Specify the subjects to be taken and the proficiency to be acquired in each.

It is inferred by the answers at hand that a broad knowledge of general studies and languages should be acquired simultaneously with a thorough proficiency in drawing, fundamental chemistry

* Questions submitted by Professor Whitaker.

† Questions submitted by Dr. Atkinson.

and analysis and that special studies pertaining to chemical engineering should be undertaken in a post-graduate course.

9.† **How much investigation should be required and of what character?**

There are only 14 answers to this question out of 22; 4 answers are negative, recommending no research work.

Ten answers are at great variance, requiring more or less research work without defining the scope.

All answers impart the impression that the meaning of "Industrial Research" is very differently interpreted and that question 9 can only be answered if question 8 has been solved.

One answer, comparatively little unless the student is particularly qualified.

10.* **Is there any reason why chemical engineering should not be taught by instruction in the applications of the fundamentals in a similar manner to other educational systems?**

Ans. Yes, 4. No, 21.

11.* **Are the subjects included under "Supplementary training" desirable or essential, and is the "Frictional" method suggested a proper way to present them?**

Ans. Yes, 18. No, 6.

12.* **Would a laboratory of engineering chemistry, equipped and managed as outlined, maintaining a rigid standard for entrance and for graduation, come nearer fulfilling the needs of men in the chemical industries?**

Ans. Yes, 17. No, 9.

13.* **Would manufacturers avail themselves of the facilities of such a laboratory for industrial research?**

Ans. Yes, 21. No, 6.

14.* **Should such a laboratory be organized and administered both in its relations to the students and to its work, as a live, up-to-date business?**

Ans. Yes, 18. No, 7.

15.† **Are both French and German essential to the chemical engineer?**

Ans. German, 15 yes.	French, 10 yes.	Neither, 9.
4 desirable.	5 desirable.	
3 very desirable.	4 very desirable.	

16.† Besides mechanism, applied mechanics and thermodynamics what mechanical engineering subjects should be included:

Steam engineering?

Ans. Yes, 15. Outline, 6. No, 3.

Machine design?

Ans. Yes, 14. Outline, 6. No, 3.

Steam power plants?

Ans. Yes, 13. Outline, 7. No, 4.

Gas power?

Ans. Yes, 12. Outline, 7. No, 3.

Works management?

Ans. Yes, 16. Outline, 5. No, 4.

17.† What electrical engineering subjects should be included:

Principles of electrical engineering?

Ans. Yes, 19. Outline, 2. No, 2.

Dynamo laboratory

Ans. Yes, 14. Outline, 3. No, 3. Desirable, 1.

Electrical measurements?

Ans. Yes, 18. Outline, 3. No, 2. Desirable, 1.

18. What civil engineering subjects should be taken:

Surveying?

Ans. Yes, 3. Outline, 3. No, 14.

Mechanics of materials?

Ans. Yes, 18. Outline, 4. No, 2.

Testing laboratory?

Ans. Yes, 16. Outline, 5. No, 2.

19. What, in your opinion, is the main cause of the failure of the present courses in chemical engineering to produce men who are prepared in the best possible way for practical work in the manufacturing establishments of the United States?

In 22 answers, there are only two which defend the present system.

Twenty answers put the fault at the colleges on the following grounds:

a. Colleges do not know what is wanted, 1.

b. Course is too short. Many answers imply this, others say it straight out.

c. Colleges try to do too much work, 3.

d. Colleges endeavor to make chemical engineers of students not fit for this profession, 3.

e. Students are not taught to think straight, 1.

i. Shortcoming of instructors, 9.

g. Lack of instruction or apparatus on a manufacturing scale and in factory appliances, 2.

Four answers put the fault with the students who fail to appreciate what is offered.

THE FOUR-YEAR COURSE IN CHEMICAL ENGINEERING

By Prof. J. H. JAMES

Read at the Chicago Meeting, June 21, 1911

It has been stated in a discussion on chemical education at one of the previous meetings of this Institute that courses in chemical engineering in the technical schools and universities of this country are in a "state of flux" at the present time. That this expresses truly the state of affairs must be realized with great force when one reads the discussions of the past few years on the best kind of training for young men intending to enter the chemical industries. We find one group of educational authorities contending that it is impossible to train the chemist, and at the same time give the engineering education necessary to make him successful in the prosecution of large-scale chemical operations. These teachers, some of them at least, seem possessed of the idea that the particular group of faculties needed in grasping the fundamentals of chemical science are so widely different from those needed by the successful mechanical or electrical engineer, that it is useless to attempt the training of a man in a course which attempts to include these even in part with a thorough course in chemistry. These authorities argue that the work of a modern plant, the operation of which involves chemical processes, should be apportioned so as to give the laboratory work on the one hand to men who have had chemical training only, and the works operation on the other to men who have had specialized training in mechanical or in mechanical and electrical engineering. Others, not quite so extreme, say that the four-year chemical course (without engineering) should be followed by a year or two of work purely engineering in character.

To grant that the extreme argument cited above is correct, is to say that the efforts being made in most of the technical schools and universities of the country are all wasted, that these institutions

are attempting the impossible in offering courses in chemical engineering, or at least in attempting to give this training in a four-year course.

Is there any ground for the statement that there is any particular set of faculties the possession or the extreme development of which, will make of the young man in our schools a good chemist, but which at the same time make him unable to assimilate and later apply the fundamental principles, of mechanical, electrical and civil engineering? We think not. In scientific work of any kind, the reasoning faculties, the powers of observation, the powers of speculation and of imagination, are all equally necessary. Such a man takes a mental pleasure first of all in the study of mathematics and the physical sciences. The man with faculties that make it possible for him to work with keenest interest on problems in civil engineering, for example, might, as far as his natural bent is concerned, have been equally as much interested in an electrical investigation, or in the study of the correlation of the various parts of a plant planned to carry out some chemical reaction on a large scale had he, by some of the trivial circumstances which too often, doubtless, determine the choice of a career, been thrown into one of these other fields. Again there are many examples in the industrial history of this country like the following: a man is trained in civil engineering and through certain conditions finds a good opening in mechanical engineering; with his technical training as a foundation he develops his mechanical engineering education alone while in practical work, and ultimately rises to the top of a profession different from the one in which he obtained his school training.

We would argue then, that as far as any particular set of faculties are concerned, there is no inherent difficulty in giving a young man a training in chemistry as well as in the fundamentals of such branches of engineering as are necessary to make the product which modern industry is beginning to recognize—the chemical engineer.

Can this training be given in four years, when the young man starts with the ordinary high-school education? We believe it can, but in order to do this successfully, there appears first of all the necessity of differentiating sharply the training of men for chemical research of the highest order, from the training of the chemical engineer or what we might term the operating chemist.

Where there are a hundred men who can grasp all the fundamental principles of engineering sufficiently to be successful operating

men, there will be one who will have the genius for research—who will, and should devote his life to investigations only. This one man, if he is to devote himself to industrial chemical research, will be better off if he takes first, instead of the usual four years' course at a literary college, a course in chemical engineering at a technical school or university, which is followed up in the good old-fashioned way by post-graduate study and a long training in pure research.

Not that the chemical engineer should not have some training in research, nor that he should not be ever on the alert to investigate and work out methods for the solution of the hundreds of problems coming up in the operation of a plant that he will meet when he goes out into practical work. But these are problems of a somewhat different character from those attacked by the research chemist who is developing new processes, or extending the boundaries of chemical science, and the tools for the attack of problems in practical work are provided in a course in chemical engineering, and their successful use depends only upon the initiative of the chemical engineer himself.

Now, as to the spirit of the chemical engineering course; we believe, first of all, that about equal emphasis should be placed on the strictly chemical subjects on the one hand, and on what might be called the engineering fundamentals on the other; mathematics and physics being regarded as the necessary prerequisite subjects for the foregoing, while economics, industrial history, works management, business law and modern language should be regarded as having both utilitarian and cultural value. It is our belief that a very thorough training in the fundamentals of mathematics through the calculus should be insisted on for chemical engineering, just as well as for other engineering courses. The point of greatest importance here, and the one which really gives the chemical engineering course its character, is the combination of the fundamentals of chemical science with the fundamentals of electrical and mechanical engineering and a limited amount of civil engineering. Here is the point at which the critics of the idea of chemical engineering education direct their fire. They say that such a course has no excuse for existence, and ask where does chemical engineering end and mechanical engineering begin. In fact, we do not have to go far afield to find noted mechanical engineers making the statement that the design and operation of chemical plants is one of the fields open to the graduate in mechanical engineering.

The answer to this is, that it is the chemical engineer only, who can by reason of his training, plan, correlate the parts, and properly operate a plant utilizing chemical reactions on the large scale. This is because the whole is fundamentally chemical in character, and the proper design of apparatus and the adjustment of the various parts are all for one end, to successfully carry out one or more chemical reactions.

Of equal value, then, surely, are the chemistry and the engineering fundamentals of the properly balanced course in chemical engineering. This means that the professors in charge of such courses in our technical schools and universities are charged with a double responsibility in connection with the training of the young men who come under their direction. And the heavier part of the responsibility is not on the side of the chemical subjects of the course, but on that of the engineering subjects which must necessarily be largely scheduled as minors in the respective departments of mechanical, electrical and civil engineering. Such professors of chemical engineering must depend largely for the success of the training his students in chemical engineering obtain, on the care and thoroughness with which these so-called minor subjects are taught in other departments. Any engineering course in a technical school or university must of necessity have a number of correlated subjects outside of the department in which the student is pursuing his engineering major, but in no other case is the dependence on other subjects quite as great as it is for the course in chemical engineering.

Those engaged in teaching technical subjects know that the average instructor does not take the interest in the teaching of a minor in the department that he does in handling a class of students taking one of the major subjects. In some cases, doubtless, this is due to the attitude of the student himself toward what he may regard as a subject of secondary importance, because it is scheduled as a minor.

The success, then, of the chemical engineering course depends on the loyal cooperation of the professors having in charge the various professional courses of the institution. Interdepartmental jealousies and difficulties lower the efficiency of the school as a whole, and in no case is the injury so great as in that under consideration. Mutual aid in school organization can be materially rendered here, by the head of each department making clear to his students the purpose and importance of their so-called minor subject work. It is usually

very easy to obtain good work in their major subjects from students, who may drag along miserably in some of their minors. This is due in part to the selection of the major and in part to the failure of the heads of the departments to properly emphasize the importance of the minor subjects.

The arrangement of the work of the chemical engineering course, the correlation of its various parts, the extent of the ground covered in major and minor subjects, all will determine whether a course that will attain the end sought can be given in four years. We believe that failure to recognize this and to properly study just what ground should be covered in each subject, has been the cause of some of the criticism that has been leveled at the idea of chemical engineering education.

It has been said that the chemical engineer should have some knowledge of mechanical engineering—how much? We would say that the work given the embryo chemical engineer by the department of mechanical engineering should include in design, the elements of machine design, giving the student enough only of the fundamental principles to enable him to design if necessary, the simpler machines used in the chemical industries. Of greater importance is a sufficient knowledge of machinery to enable the student to install and operate machines and apparatus of various types. While he cannot design a steam engine, he should know all the points involved in its successful care and operation. The student cannot have the time while in the mechanical engineering department to study in detail the principles of the design of pumps, blowers, meters, etc., but by lectures and laboratory work, he can learn enough about them, to select, order, install and have properly cared for when he goes into practical work.

In like manner, in electrical engineering, the student does not take up the work in sufficient detail to enable him to design dynamos and motors, but should learn enough about the principles of, and have enough practice in electrical engineering, to install and operate all such electrical appliances as will come into his field of practical work. He should be able without hesitation, for example, to make the layout for an electro-plating plant; to discuss intelligently with the representatives of electrical manufacturing establishments, the dynamos and other electrical apparatus needed for his plant; and when the outfit arrives he should be able to superintend its installation and successful operation. And all this without being

an electrical engineer, trained in all the minute details of design of dynamos and other electrical apparatus.

In civil engineering, the elements of structures should be scheduled for the chemical engineering students. This must of necessity be placed at such a point in the course that the student has completed his mathematics. The student should be given sufficient work here to enable him to lay out a simple factory building and to calculate allowable loads on floors and platforms around the plant. The subject of materials and material laboratory from the standpoint of the civil engineer is also a minor and is best given by the civil department.

With all of the above engineering subjects taught the students in chemical engineering by outside deaprtments, there still remains a considerable amount of engineering that must be taught by the professor of chemical engineering himself. While this does of necessity partake somewhat of the character of patchwork, since it takes up points in apparatus construction and other subjects not touched on in the ground covered in the engineering minors noted above, it is equally important. This will include a detailed study of resistance to various chemicals possessed by materials of construction from the standpoint of their use in construction of pipe lines, conduits, vats, autoclaves, stills, fractionating columns, absorption apparatus of various types, furnaces adapted to various uses in chemical manufacturing, etc., etc. Practice in calculation of heat-transmission in the various connections that interest the chemical engineer should be taken up here.

In direct connection with the above, there comes the problem of laboratory work in chemical engineering. Our student has up to this point had all of the ordinary chemical laboratory work, general chemistry, qualitative analysis, elementary and technical quantitative analysis, organic and inorganic preparations; but what can be given the student while in school to prepare him to any extent in the direction of handling large-scale chemical apparatus? On this point we have had much discussion of late, and the author is convinced that the views expressed by Professor W. H. Walker * of the Massachusetts Institute of Technology and by Professor James R. Withrow † of the Ohio State University in a recent number of the *Journal of the American Chemical Society*, show the most

* *Journal of the American Chemical Society*, April, 1911.

† *Ibid.*

practicable and efficient method in dealing with this problem in chemical engineering education. The operation of apparatus on a semi-industrial scale, with the idea of merely "sloping through" and making soda ash, barium sulphate, or soap, with no attention to the fundamental operations and the most efficient means of carrying them out, is certainly a waste of time. And we do not believe with Professor M. C. Whitaker * of Columbia, that proper laboratory work in chemical engineering consists in large-scale manufacturing in a fully equipped plant. Is this any more of necessity for the training of the chemical engineer, than for the civil engineering department to teach structural work by the actual erection of a skyscraper on the campus? It would seem that a proper balance can be found between actual large-scale operations on the one hand, and ordinary laboratory work on the other.

The proper application of various chemical engineering devices to the different steps of a chemical manufacturing process, as pointed out by Walker and Withrow, can be carried out by the student with semi-industrial scale apparatus in such a way as to make good, hard, valuable work for him, for he will have calculations, studies of efficiencies and comparisons to make, and with such work carefully planned we instructors will do much to remove the criticism that has heretofore been directed against laboratory courses in industrial chemistry and chemical engineering, much of which has been deserved.

In conclusion, then, we believe that it is possible to train young men for profitable and efficient work in the field of chemical engineering, in a four-year course; that this requires the closest attention to details in the proper correlation of subjects; that it requires the friendliest cooperation on the part of the instruction staff in the other engineering departments.

In this, the youngest of all the engineering professions, the training is from necessity the broadest offered in any.

J. H. James,
Department of Chemical Engineering,
Carnegie Technical Schools,
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* *Journal of Industrial and Engineering Chemistry*, January, 1911.

THE QUESTION OF FIVE-YEAR ENGINEERING COURSES AT OHIO STATE UNIVERSITY

By Prof. JAMES R. WITHROW

When Professor J. C. Olsen, Secretary of the Institute, invited me to present the results of the work of the Five-Year Course Committee of the College of Engineering, Ohio State University, I had expected to broaden the subject a little, from the Institute's point of view, by making it a discussion of the length of the chemical engineering course. In fact I prepared the major portion of such a paper, but was compelled to discard it and stick more closely to the original text, because the work of tentatively extending our own chemical engineering course was never completed. This was owing to the fact that the best interests of all concerned were conserved by remodeling the various engineering courses along the lines of certain principles. It is with the developments of this Engineering College policy in reference to course expansion that this paper undertakes to deal, rather than with the specific case of the chemical engineering course itself.

At Ohio State University the College of Engineering has had committee reports along this general line for several years. Some of these reports were very thorough and voluminous. A recent case, however, of a graduate chemical engineering student demanding the privilege of pursuing advanced work in chemistry and additional work in engineering for which the M.S. degree should be given, occasioned a discussion of post-graduate degrees and the work therefor. This led to the appointment of a new Committee on Five-year Courses in the College of Engineering by Dean Edward Orton, Jr., in October, 1910. The committee was constituted as follows:

Professor F. H. Eno, civil engineering, chairman; Associate Professors R. C. Purdy, ceramic engineering; C. St. J. Chubb, architecture; H. Judd, mechanical engineering; James R. Withrow, chemical engineering, secretary; Assistant Professor, W. H. Minor, mine engineering.

It will be noticed that each man appointed represents some one of the courses leading to a degree in the Engineering College. They were instructed by the Dean that they should not merely stand for their own ideas, but should also represent the sentiment of their departments on all important matters.

The committee started work by sending each member back to his respective department to have these departments formulate a five-year course such as would meet the demand for such a course for his kind of engineering. There was a twofold object in this procedure: 1st, to crystallize the important reasons why such a course was desirable, and 2d, to bring to the attention of individual departments their exact capacity for presenting or offering the lengthened course. This procedure at once developed the fact that one of the departments which so long favored five-year courses was now convinced that the policy would be a bad one for it. It also developed that there were more different reasons for five-year courses than there were engineering courses and that these reasons were often divergent. There was also considerable sentiment against the practice of giving the professional degree (C.E., M.E., etc.) for four years of undergraduate work.

Reasons for Five-year Courses

Some of the important reasons advanced for desiring five-year courses were as follows:

1. That the number of hours of work required of students in the Engineering College is so great that the *average* student cannot do justice to the subjects required of him, let alone acquire much breadth of view in matters of importance in the social complex.

It was pointed out that a man should not be a mere automaton of mathematical and theoretical applications, but should be educated broadly enough to know something of society and its requirements and problems, and be able to carry himself easily in society, business and public life. The time to acquire this knowledge was said to be in the formative period of college life. In order to show the opportunity given him to obtain these accomplishments, the schedule of an engineering freshman was calculated on a five-day basis.

Time given for sleep	8 hrs.	00 mins.
Time given for eating	1 "	30 "
Time given for recitation	2 "	46 "
Time given for laboratory	2 "	00 "
Time given for military drill	0 "	24 "
Time given for gymnasium	0 "	48 "
Time given for preparation	6 "	20 "
Total	21 hrs.	48 mins.

This allows him

For toilet and dressing	0 hrs.	20 mins.
News of the day	0 "	10 "
Lost time and recreation	1 "	42 "
Total	24 hrs.	00 mins.

This makes the student a 93 *per cent efficient* man as he *leaves* the high school. The average of the other years is no better, because of the heavier quality of work required.

2. The professional subjects are becoming so specialized that within the bounds of the present four-year courses, many important subjects cannot be taken up at all. To illustrate:

In mechanical engineering, the subjects of gas engineering and automobiles; in naval architecture, submarines; in electrical engineering, wireless transmission; in civil engineering, bacterial sewage disposal and garbage treatment.

As the parent stock, civil engineering has been sub-divided into mechanical engineering, marine engineering, electrical engineering, steam turbine engineering, chemical engineering, architecture; mining engineering into metallurgical engineering, sanitary engineering, railroad engineering, hydraulic engineering. So will these various branches split again in the near future. Even now must be considered aeronautics, aero-telephonic engineering, etc. It was said to be necessary to meet this demand.

3. The feeling was that all engineers should have some definite training in the principles of the law of contracts and common business law.

4. Additional liberal studies are desired by many to accompany the more technical or special topics so as to assist in developing in

the engineer a feeling of his relation to the social complex of which he is a member.

5. Opportunity for a "two-year common to all" schedule in fundamentals followed by three years of specialization in the subdivisions respectively, civil engineering, mechanical engineering, etc.

6. Broad preparation in the humanistic studies such as might arise from a two degree arts-engineering curriculum.

7. Opportunity for a graduate in mechanical engineering, etc., to pursue additional work in an allied branch of engineering and receive therefor the degree attached to that allied branch (electrical engineering, for instance).

8. Opportunity for applying the principle of cooperation between the colleges throughout the State of Ohio and our College of Engineering. It would be a very useful thing to the State to exhibit an inclination to cultivate cooperation between State-wide distributed institutions by offering parallel engineering courses (or some other device) for accepting men with one or two or more years in such suitable colleges.

Situation at Other Institutions

A limited number of circulars of inquiry were sent out by the committee to other institutions (widely scattered geographically) to ascertain their point of view on this matter. The institutions addressed were as follows:

University of Pennsylvania, Massachusetts Institute of Technology, University of Michigan, Harvard University, Purdue University, Stevens Institute, Cornell University, University of Illinois, University of Wisconsin, University of California, Columbia University, University of Minnesota.

The following is a copy of the reply circular sent to the institutions mentioned:

October, 1910.

James R. Withrow,
Secretary Committee on Five-year Courses, College of Engineering, Ohio State University.

Sir:

The following replies are made to the attached questions concerning five-year courses in our engineering departments:

I. Do you have any five-year courses in engineering?

II. If you have five-year courses, is the fifth year a continuation of the fourth year, giving more advanced and technical subjects, or does it contain a combination of technical and fundamental or general work?

III. Is the five-year course paralleled by a distinct and different four-year course?

IV. To what extent do you use in five-year courses the idea of one or two years of preliminary (and " common to all ") work in fundamentals?

V. Are degrees given at the end of both fourth and fifth years? Please indicate their designation.

VI. What proportion of students elect the five-year course or the fifth year, as the case may be?

VII. Remarks.

The answers revealed a remarkable divergence in the practice of these institutions on many of the points of inquiry. A considerable number of the institutions have courses longer than four years (Cornell, Minnesota, Harvard, Wisconsin and Michigan). The answers to the questions concerning the character of the work in the extra year or years showed nearly every combination of possibilities. In several institutions the five-year course was paralleled by a distinct and different four-year course. Several also believed in the principle of one or two years of preliminary (and " common to all ") work in fundamentals as we use it in our freshman year at Ohio State University. In the matter of degrees it was usual to grant a degree at the end of the fourth year and follow with a more advanced degree, if the extra year was advanced work. A number (like ourselves) still give the engineering degree, C.E., etc., for four years' work (Cornell, Columbia, Stevens). Most, however, gave B.S. in the course taken. For the second degree there was a fairly even distribution between the Master's degree and some form of the professional degree of C.E., etc. The excellent report of June, 1910, on Engineering degrees, by the Society for the Promotion of Engineering Education, thoroughly covers the degree situation in American institutions.

The final report of the Ohio State University Five-year Committee, as accepted, was as follows:

Report of the Committee on Five-year Courses

In accordance with instructions received from the faculty of the College of Engineering, your committee begs leave to recommend:

I. That the undergraduate degrees given in this college shall be:

Bachelor of Architecture,
Bachelor of Ceramic Engineering,
Bachelor of Chemical Engineering,
Bachelor of Civil Engineering,
Bachelor of Electrical Engineering,
Bachelor of Industrial Arts,
Bachelor of Mechanical Engineering,
Bachelor of Engineering in Mining.

Notice of these changes in degrees shall be published at once and shall take effect in 1915. Departments whose students wish to avail themselves of these degrees earlier, may do so upon the approval of the faculty.

II. That any student may receive an additional Bachelor's degree in any other department of the College of Engineering than that in which he takes his first degree by performing a prescribed amount of work in the course leading to the additional degree, besides the work required in his own department for a degree.

The specified work shall not be less than thirty hours for any additional bachelor degree, while more than thirty hours will be necessary in correlating some of the departments. The additional amount of work required for the two degrees shall be less than the sum of the studies *not common* in the separate courses to be correlated, except that not less than 30 hours shall in any case be required.

III. That the courses of study and hours required to make provision for the additional Bachelor degrees in any of the departments shall be devised by committees of three, consisting of the Dean of the College of Engineering and one representative from each of the departments interested in giving the two degrees.

The general provisions so devised shall be published and made available at the earliest possible date.

IV. That the College of Arts, Philosophy and Science be requested to appoint a committee to sit with a similar committee of the College of Engineering, to consider five and six years arts-engineering courses, said courses to lead to two degrees. The committee representing the College of Engineering shall consist of three mem-

bers of this faculty appointed by the Dean. This committee of the College of Engineering shall also investigate the subject of arts-engineering agreements with other colleges in Ohio.

V. That the College of Engineering organize a graduate school. That this graduate school be an organic part of this college, and subject to regulations approved by this faculty. It shall have no faculty separate from the faculty of this College.

VI. That the administration of the work of the Graduate School of the College of Engineering shall be vested in a standing committee of this college to be known as the Administrative Board of the Graduate School of the College of Engineering.

VII. That the Administrative Board of the Graduate School of the College of Engineering shall consist of the Dean of this college and *six* members of the faculty of the College of Engineering appointed by the Dean as follows: Two to be appointed for a term of one year, two for a term of two years, and two for a term of three years, their successors thereafter to be appointed for terms of three years.

VIII. That the Administrative Board shall elect its own chairman and secretary from its membership. But it is not the desire of the faculty that the Dean be required to act as chairman.

IX. That the Administrative Board shall be charged with the supervision and administration of all graduate work leading to advanced degrees and the recommendation of candidates for professional degrees. All recommendations for degrees shall be made to this faculty.

X. That the Administrative Board shall be required to make an annual report at the May meeting of the faculty of the College of Engineering, upon the status of the work under its supervision, together with such suggestions and recommendations as its experience during the year may call forth.

XI. That the degree granted by the College of Engineering, upon the satisfactory completion of one year of advanced work in residence, shall be Master of the course in which the major work has been taken, such as Master of Mechanical Engineering, etc. This advanced work shall be such as may be prescribed by the department in which the advanced degree is to be taken, subject to the approval of the Administrative Board.

XII. That upon application to or nomination by the Administrative Board the professional engineering degree of Civil Engineer,

Mechanical Engineer, etc., be granted to graduates of this college for four years of acceptable professional experience, provided that one holding the Master's degree in engineering may be credited with two years of this time. Thesis shall be required for this degree, but this requirement may be waived at the discretion of the Graduate Board.

Also, that a graduate holding a Bachelor degree in a branch of engineering, who subsequent to obtaining that degree shall have had at least one year of practical experience in connection with that branch of engineering in which his major work was taken, may upon completion of one year's study in residence and the submitting of an approved thesis obtain a professional degree in the particular branch of engineering in which he is qualified, provided that the year's study shall consist of not fewer than thirty semester hours, not including thesis, and that the course of study and thesis shall have been approved by the Graduate Board and by the Department or Departments concerned; also that the practical experience shall have been considered and approved by the Graduate Board.

Explanatory Notes

In explanation of the foregoing recommendations, the following notes are appended:

Recommendation I is a result of the long-felt desire on the part of the Engineering College to do three things with reference to the title of the degrees granted by that college:

(1) To abolish the anomaly of designating as "Engineer" a graduating senior.

(2) To eliminate several ambiguous words and phrases in some degrees as now granted.

(3) To have the degrees express in no uncertain terms, not only the course in which the major part of the work was taken, but also the degree of proficiency of the graduates in that work.

Recommendations I and II are attempts to assist the student who desires to spend a fifth year in college, not to specialize further in the course in which his Bachelor's degree was taken, but to broaden his engineering point of view by taking additional engineering work. Although such work might be considered post-graduate work, nevertheless, it could hardly be deemed worthy of an advanced degree. Provision should, therefore, be made whereby a Bachelor

of one kind of engineering could receive another Bachelor degree by performing prescribed work in another engineering course.

Regarding *Recommendations V to XI* inclusive: It is generally agreed that advanced or technical studies are desirable. It is obvious, therefore, that opportunity should be given the willing student to pursue these advanced studies. As this college is desirous of increasing the amount of fundamentals and of liberalizing studies, it is evident that much of the technical work must be given in an extra college year. The sentiment of this college does not deem it wise, however, to require five years' work of all who graduate, but merely furnish to those students who care to avail themselves of it the opportunity of an additional year's work.

Therefore this college is compelled to offer an advanced degree for the extra or fifth year, which becomes under these conditions a bona-fide graduate year in residence.

Recommendation XII postpones the granting of the degree of " Engineer " until the candidate has become an engineer, and merely places our college in line with the growing tendency of the institutions of the country.

Respectfully submitted,

Frank H. Eno, *Chairman,*	Wells H. Minor,
James R. Withrow, *Secretary,*	John H. Hunt,
C. St. John Chubb,	Ross C. Purdy.
Horace Judd,	

These propositions were discussed as the principles which, if adopted, should guide the reconstruction of the individual courses. The amended report as here transcribed was adopted by the College of Engineering. Action by the university faculty on the Graduate School portion was postponed until the larger question of the creation of a graduate School or College for the whole university should be settled. This action of the Engineering College seems therefore to have been a stimulus to the authorities, who have allowed the larger question to drift unsolved for several years.

Other Results, Direct and Indirect

The university has established a Graduate School with a Dean. This school has charge of all graduate work in the Engineering as well as Arts and other Colleges.

As a result of the recommendations of the report and the discussion provoked during the work, a committee was set to work on the possibility of keeping the first year uniform if the foreign language requirement were omitted. The argument had been made that as a single year of foreign language was insufficient to give a working knowledge of the language and brought no cultural value, then as a mere mental discipline it might be replaced by an equally difficult subject which was fundamental to some advanced engineering work. The result of the deliberations on this problem was the retention of the foreign language by a majority of one vote.

As a result of the work of a third committee the course in industrial arts was dropped with the recommendation that as speedy a development as possible should be encouraged of the five-year arts-engineering courses to fit students for administrative duties in the industrial world.

A fourth committee was appointed by the Dean to study the matter of establishing an engineering experiment station at the university.

Finally the joint committee appointed to consider and devise a combination arts-engineering course leading to the degree of Bachelor of Arts and the appropriate engineering degree brought in a report which was adopted by both the College of Arts, Philosophy and Science and the College of Engineering, and put into operation.

The new combination course requires the same entrance requirements as the Arts College except that physics is also required. The student may register in the College of Engineering when he has completed of the 120 hours required for the A.B. degree, at least ninety hours' work, exclusive of military drill and physical education. The ninety hours shall include the following subjects:

Algebra Trigonometry Analytical geometry Calculus	20 credit hours *
General chemistry Qualitative analysis	8 credit hours
French, German or Spanish	16 credit hours

* A credit hour is one lecture or recitation hour or a two- or three-hour laboratory period per week for one semester.

English composition	4	credit hours
Social science	6	"
Biological science	6	"
Physics	10	"
Mechanical drawing	5	"
Arts, electives	15	"
Total	90	credit hours

Eighty of these semester hours in the above work must be strictly arts work and the other ten may be from the electives permitted by the Arts College from the studies of the other colleges.

When the candidate has obtained 124 hours' credit in the two colleges exclusive of military drill and physical education, 100 semester hours of which are accepted by the Arts College, the candidate shall receive the A.B. degree. This will ordinarily be at the end of one year's residence in the College of Engineering. Mechanics, ten hours, are credited toward the Arts degree. At the end of two years more, or a total of six years, by doing the regular work required, the candidate will have completed the requirements for any of the engineering degrees.

The Committee of the University Faculty on Cooperation with other Colleges was instructed to confer with the other colleges of the State of recognized standing with a view to arranging combination courses with the College of Engineering. The following advantages to the cooperating college should be noted:

1. By increasing the enrollment of local students, it would increase the local interest in the institution.

2. It would add to the alumni rolls some who would otherwise go directly from high school to a college of engineering.

3. It would prolong the attendence of others who now transfer to a college of engineering at the end of one or two-years' residence.

4. It would result in a four-year attendance of those students who after entering the combination course discover that they are not especially fitted to become engineers.

SUMMARY OF THE RECENT PROGRESS IN POLICY OF THE COLLEGE OF ENGINEERING, OHIO STATE UNIVERSITY

I. Principles have been laid down for guidance in reconstructing the individual engineering courses.

II. Five-year courses are made possible but not mandatory. The possible five-year arrangements for which provision has been made are:

(*a*) Four years leading to the Bachelor's degree in one form of engineering followed by work in an allied course leading to the Bachelor's degree in the allied branch.

(*b*) Four years' work leading to the Bachelor's degree followed by a year's advanced work in residence for the Master's degree.

III. Granting of the professional degree, only after practical industrial service.

IV. Six-year Arts-engineering arrangement leading to A.B. at end of four years and Bachelor of some form of engineering at end of six years.

OHIO STATE UNIVERSITY,
June 17, 1911.

Since writing the above article the degree of Master of Civil Engineering, Master of Chemical Engineering, etc., has been changed by the new Graduate Council of the University to Master of Science.

Since the opening of the University this fall an Engineering Experiment Station committee has formulated plans and carried into operation the publication of bulletins of interest to engineers, calling these for the present "Bulletins of the College of Engineering," as we have not yet instituted an experiment station. So far the following bulletins have been issued or are in press:

1. "Some Observations on the Qualities of Paving Bricks," by Edward Orton, Jr.

2. "The Coefficient of Expansion and Contraction of White Ware Body Mixtures," by Ross C. Purdy and Amos P. Potts.

3. "Standardization of the Rattler Test for Paving Bricks," by M. W. Blair and Edward Orton, Jr.

4. "Superheated Steam," by E. A. Hitchcock.

A COURSE IN CHEMICAL ENGINEERING EDUCATION

Prepared in Accordance with the Vote of the Institute on the Questionnaire of December, 1910

By J. C. OLSEN

Read at the Washington Meeting, December 22, 1911

The reports of the Committee on Chemical Engineering Education, the various papers which have been read on this subject, the discussions and more particularly the vote of the Institute on the questions submitted in the circular letter No. 2 which has been published in the October, 1911, Bulletin, has given a fairly concrete idea of what the members of the Institute consider necessary and desirable in a Course on Chemical Engineering Education.

It would probably be difficult to find a body of men whose opinion on the questions raised could be considered of greater value than that of the members of the American Institute of Chemical Engineers. The members of this Institute have all qualified for admission by presenting evidence of education along chemical and engineering lines equivalent to at least a four-years' college course. A very considerable proportion hold in addition the degree of Doctor of Philosophy. The members must also present evidence of a considerable amount of successful experience in technical chemical work. Some of the members occupy important positions in colleges and universities, while many others have had more or less extended experience in teaching. Almost all the members employ and supervise the work of young chemists. In answering the questions on Chemical Engineering Education, members have no doubt specified the courses which from their experience seemed necessary and desirable without any thought as to the length of the resulting course or how it would work out in practice. It seemed desirable in closing the discussion on this subject to present a course of study designed to carry out the views of the Institute.

A COURSE IN CHEMICAL ENGINEERING*

Prepared in accordance with the vote of the Institute on the Questionnaire of Dec., 1910.

FRESHMAN YEAR

Hours a week	FIRST SEMESTER	Course Number	Hours a week	SECOND SEMESTER	Course Number
2	Rhetoric and Composition.	18	3	Modern English Prose and Composition.	20
2	Fiction and the Drama.	19			
2	Scientific German.	24	2	Scientific German.	24
2	Higher Algebra.	31	5	Analytical Geometry	32
3	Plane and Spherical Trigonometry	30	1	Elementary Physical Chemistry.	11
1	Chemistry.	1	10	Qualitative Analysis.	2
10	Qualitative Analysis. 3 Lectures 7 Laboratory	2		3 Lectures 7 Laboratory	
2	Mechanics and Heat.	50	2	Mechanics and Heat.	50
4	Mechanical Drawing.	35	4	Mechanical Drawing.	35
2	Descriptive Geometry.	36	2	Descriptive Geometry.	36
2	Physical Training.	55	2	Physical Training.	55

SOPHOMORE YEAR

Hours a week	FIRST SEMESTER	Course Number	Hours a week	SECOND SEMESTER	Course Number
3	Types of English Literature; Prose.	21	3	Types of English Literature; Verse.	22
2	German.	25	2	German.	25
2	European History.	26	2	Recent European History.	27
9	Quantitative Analysis. 3 Lectures 6 Laboratory	7	3 2 5	Sound and Light. Laboratory Physics. Advanced Qualitative Analysis.	52 53 3
3	Electricity and Magnetism.	51		2 Lectures 3 Laboratory	
2	Laboratory Physics.	53			
6	Blow Pipe Analysis. 1 Lecture 5 Laboratory	4	3	Calculus.	33
3	Calculus.	33	1	Experimental Engineering.	41
			5	Electrical Measurements	54
			4	Machine Drawing.	37

JUNIOR YEAR

Hours a week	FIRST SEMESTER	Course Number	Hours a week	SECOND SEMESTER	Course Number
5	Analytical and Applied Mechanics.	34	2	Mechanism.	39
2	Economics.	28	16	Quantitative Analysis. 3 Lectures 13 Laboratory	7
13	Quantitative Analysis. 3 Lectures 10 Laboratory	7	3	Mechanics of Materials.	14
			3	Vise Work.	40
4	Mineralogy 2 Lectures 2 Laboratory	10	3 4	Mineralogy. 2 Lectures 2 Laboratory	10
6	Machine Design.	38		French.	23
3	French.	23			

* Since reading this Course at the Washington Meeting, a number of changes have been made consisting mainly of rearrangements of the subjects. Some of the changes were suggested by the discussion at Washington.

FOURTH YEAR

Hours a week	FIRST SEMESTER	Course Number	Hours a week	SECOND SEMESTER	Course Number
3	Thermodynamics	42	3	Fuel, Gas and Water Analysis	5
4	Physical Chemistry	11		1 Lecture	
	2 Lectures			2 Laboratory	
	2 Laboratory				
16	Organic Chemistry	12	13	Organic Chemistry	12
	3 Lectures			3 Lectures	
	13 Laboratory			10 Laboratory	
3	Theoretical Hydraulics	15	4	Industrial Chemistry	8
4	Industrial Chemistry	8		2 Lectures	
	2 Lectures			2 Laboratory	
	2 Laboratory		3	Testing Materials Lab.	44
			4	Water Analysis	7
				1 Lecture	
				3 Laboratory	
			3	Steam Engines	46

FIFTH YEAR

Hours a week	FIRST SEMESTER	Course Number	Hours a week	SECOND SEMESTER	Course Number
2	Power Plants	47	4	Thermo-Chemistry	13
3	Hydraulic Laboratory	45		2 Lectures	
2	Engineering Economics	29		2 Laboratory	
2	Gas Power	49	4	Power Plants	47
1	Refrigeration	43	1	Works Management	48
5	Metallurgy	9	3	Dynamo Electricity	16
	2 Lectures		3	Dynamo Laboratory	17
	3 Laboratory		15	Thesis	
15	Thesis				

In preparing the course submitted herewith, a number of assumptions have been made. It is assumed that the student comes to college with a good high school education, including the following subjects: English, History, Elementary Physics and Chemistry, Elementary and Advanced Algebra, Plane and Solid Geometry and Plane Trigonometry, Elementary French and German. Only the graduates of our best high schools can meet these requirements, and in so far as students are deficient, the course submitted must be lengthened.

Nothing has been said in the educational discussion with reference to the necessity of training in English. American universities and technical schools differ widely in this respect, some giving absolutely no instruction in the use of English or History, while others devote a great deal of time to this subject. The attempt has been made in the course submitted to take a middle ground in this respect.

The amount of time given to each subject is that which has been found by experience at the Polytechnic Institute of Brooklyn, to be necessary to give the proficiency required by the Institute vote.

In this respect, the experience of other schools is no doubt similar. Thirty hours per week of required laboratory and class work has been taken as the standard. While some students can do more than this, a higher requirement would, no doubt, result in the sacrifice of thoroughness on the part of the average student. There is no difficulty in finding profitable work for the brilliant student.

The chemical subjects are given early in the course together with mathematics, physics and the languages, while most of the engineering subjects are given in the last year.

It will be noted that five years is required for this course. As outlined, the course is probably heavier than is ordinarily carried in the average American college. Taken in connection with the fact that the entrance requirements called for are quite high, it will probably be found that in many localities the course would require six years. It is interesting therefore to conclude that the Chemical Engineering education called for by the American Institute of Chemical Engineers requires a college course of from five to six years. In practice it will, therefore, probably be found desirable to grant a degree such as B. S. in chemistry at the end of four years and consider the remainder of the course as post graduate work and grant the degree of Chemical Engineer at its conclusion.

A study of the courses in Chemical Engineering in eight leading American universities and technical schools has been published in the November issue of the *Chemical Engineer*, showing the amount of time given to the various branches of study as grouped under four headings, viz., Letters, Science, Engineering and Chemistry. In estimating the time given to each group of studies, $2\frac{1}{2}$ hours of laboratory time was considered equal to one recitation or lecture hour under the assumption that $1\frac{1}{2}$ hour's preparation would be given to the subject of the lecture or recitation.

The subjects specified in the course presented in this paper were grouped in the same manner, the time allowed to each subject estimated and the percentage of the total time given to each group of studies calculated with the following result:

Letters 15 per cent, Science 20 per cent, Engineering 25 per cent, Chemistry 40 per cent. It is interesting to note that this is exactly the average of the amount of time given to these subjects in four of the courses given in the Schools studied in the article published in the *Chemical Engineer*.

A brief description of the individual courses follows:

1. Advanced Inorganic Chemistry. A general review of the principles of inorganic chemistry is given in this course. Freshmen one hour, first semesters.

2. Qualitative Analysis. A systematic course of instruction in basic analysis. Freshmen, lectures three hours, laboratory seven hours, both semester.

3. Advanced Qualitative Analysis. A systematic course in qualitative analysis both basic and acid. The analysis is chiefly that of ores, slags, alloys and minerals. Although the course is pursued in the main in the laboratory, it is supplemented by lectures. Sophomores, lectures three hours, laboratory seven hours, second semester.

4. Blow-Pipe Analysis. A thorough course in the various methods of studying reactions before the blow-pipe. Sophomores, lectures one hour, laboratory five hours, first semester.

5. Fuel, Gas and Water Analysis. A course involving the determination of the proximate composition and the heating values of commercial fuels, the analysis of gases for the commercial production of light, heat and power, and the analysis of boiler feed waters for scale-forming ingredients. The laboratory work is supplemented by lectures on fuel composition and distribution and on the chemical methods of purifying boiler waters. Fourth year students in Chemical Engineering, lectures one hour, laboratory two hours, first semester.

6. Water Analysis. In this course the suitability of various waters for drinking purposes and for use in boilers is determined. The chemical examination of potable waters is supplemented by a bacteriological examination, and methods for adapting waters to manufacturing purposes are discussed. Fourth-year students in Chemical Engineering; lectures one hour, laboratory three hours, second semester.

7. Quantitative Analysis. An extended course in quantitative analysis, gravimetric, electrolytic, and volumetric. Especial attention is given to testing the balance, calibration of weights, and volumetric apparatus. Pure salts and simple compounds are first analyzed. Ores, minerals and technical products are then studied. Later in the course, optional courses for specialization are offered in the analysis of iron and steel, coal, water, fuels, oils and gases. Lectures three hours, laboratory six hours, first semester, Sophomore year; lectures three hours, laboratory thirteen hours, first semester; lectures three hours, laboratory thirteen hours, second semester, Junior year.

8. Industrial Chemistry. A study of chemical processes upon a manufacturing scale, and under conditions widely different from those existing in laboratory experimentations. Enough of the history of processes is given to show the advance in chemical industry to the present time; any by-products, the utilization of waste products, and their influence upon successful manufacturing are expecially considered. The actual conditions of the prosecution of factory work are examined by means of excursions to chemical plants. Fourth-year students, lectures two hours, laboratory two hours, second semester.

9. Metallurgy. A study of the ores of copper and iron and the various processes for their smelting and refining. The qualities and uses of the metals are treated in detail. Especial attention is given to the results of the microphotographic investigation of steels which have been subjected to various conditions of heating and cooling. Fifth-year students, lectures two hours, laboratory three hours, first semester.

10. Mineralogy. A study of crystallography and the application of knowledge of the crystal systems so derived in determining given minerals. A practical study of minerals by blow-pipe analysis and other methods. Models of gass and wood are used to illustrate the lectures. Juniors, lectures two hours, laboratory two hours, both semesters.

11. Physical Chemistry. A study of the development of chemical theory and its influence upon industrial progress. Especial attention is given to molecular weight determination and to the theory of electrolytic dissociation. Fourth-year students, two hours, first semester.

12. Organic Chemistry. A detailed study of organic chemistry with special reference to its theory, involving a large amount of practical work in the preparation and purification of typical organic compounds, together with considerable practice in ultimate analysis. Fourth-year students in Chemical Engineering: lectures three hours, laboratory thirteen hours, first semester; lectures three hours, laboratory ten hours, second semester.

13. Thermo-Chemistry. In this course are presented the principles governing the transformation of chemical energy into heat and the electrical methods of producing chemical compounds. Calorimetric determinations of the heat of combustion of fuels and chemical compounds are made in the laboratory. Fifth year students, lectures two hours, laboratory two hours, second semester.

14. Mechanics of Materials. A study of the relation between stresses and strains, and of the common theories of flexure, torsion, column action, and riveted joints. The elastic limit, working, and ultimate strength of engineering materials are considered at length, and methods of figuring reactions, moments, and shears in single and continuous beams under fixed loads are thoroughly discussed. Many problems are assigned, covering the various points treated, and especially the design of beams, columns, and torsion members. Juniors, three hours, second semester.

15. Theoretical Hydraulics. A study of elementary hydraulics dealing with the static and dynamic properties of water. Hydrostatics, the flow of water through orifices, tubes and nozzles, the flow in pipes and open channels, the flow over weirs, and the measurement of flow, are considered. The course shows the losses that take place and how these are allowed for by experimental coefficients, and at the same time it shows the limits within which formulas can be used. The work is supplemented by practice in the hydraulic laboratory Fourth-year students, three hours, first semester.

16. Dynamo Electricity. The theory of the operation and installation of direct-current and alternating-current electrical machinery, together with a discussion of the conditions affecting its operation and efficiency. This course combined with laboratory exercises is designed to enable the student intelligently to select, install, and operate electrical apparatus. Fifth-year students in Chemical Engineering, three hours, second semester.

17. Dynamo Laboratory. A course involving general commercial tests on the operation, regulation, and efficiency of direct-current dynamos and motors; of single phase and polyphase generators; of synchronous, induction, and series alternating current motors; and of converters and transformers. Fifth-year students in Chemical Engineering, three hours, second semester.

18. Rhetoric and Composition. A course in the principles and practice of English composition. Freshmen, two hours, first semester.

19. Studies in Fiction and the Drama. A course involving the reading and discussion of typical plays, short stories, and novels, with a view to kindling the student's interest in literature, and to deepening his appreciation of it as a criticism of life. Some attention is given to current literature as presented in the best periodicals. Freshmen, two hours, first semester.

20. Modern English Prose and Composition. A course involving the reading of selected works of essayists and novelists of the nineteenth century, together with constant practice in composition. Written class exercises, critical reports, and themes in emulation of the style of great masters are required. Freshmen, three hours, second semester.

21. Types of English Literature. Prose. The novel, the essay, the biography, and other prose types are considered as representative of the type, the period, and the author; but, although the course furnishes a certain amount of mere information, its chief aim is the appreciation of the masterpieces as pure literature. Sophomores, three hours, first semester.

22. Types of English Literature. Verse. This course is a continuation of the one preceding, with reference to the meaning and the development of such types of verse as the narrative poem, the drama, the didactic poem, the satire and the lyric. Sophomores, three hours, second semester.

23. French. A course involving the rapid review of French syntax, exercises in idioms, practice in prose composition, and conversational drill upon literary and historical topics and current events, together with a special study of nineteenth century French scientific literature in the works of representative authors. Juniors, three hours, both semesters.

24. Scientific German. A course involving a rapid review of German syntax, exercises in idioms, prose composition, and conversational drill toward acquiring a copious scientific vocabulary, together with the reading of selected scientific monographs. Freshmen, two hours, both semesters.

25. Second Year German. A study of the prose writers of the classical and the modern period, with especial reference to reading in science, and with some consideration of the development of German literature. This course requires the translation from English into German of long selections, the frequent reproduction in the student's own words of the texts read, and ample conversational drill. Sophomores, two hours, both semesters.

26. European History. A course dealing with the development of the chief European nations from the Reformation to the French Revolution. Sophomores, two hours, first semester.

27. Recent European History. A course dealing with the development of the chief European nations since the commencement of the French Revolution, with a view to emphasizing the principal features of contemporary world politics. Sophomores, two hours, second semester.

28. Economics. The elements of economics, involving a study of economic theory, the organization and development of industry, and the distribution of wealth. Juniors, two hours, first semester.

29. Engineering Economics. A course of lectures, recitations and reports upon the organization and development of transportation systems, the nature

and the position of corporations in the industrial fields, the question of conservation of natural resources, the relations of organized labor to the development of industry. Fifth-year students, two hours, first semester.

30. Plane and Spherical Trigonometry. A review of the theory of the trigonometric and circular functions, a study of the ratio definitions as generalized by the introduction of the co-ordinate system; the application of trigonometry to problems in plane surveying, with and without the use of logarithms; a study of trigonometric transformations as illustrated in verification of identities; the solution of trigonometric and circular equations, and a study of the graphs of the several functions. So much of the theory of spherical trigonometry as is necessary to the solution of spherical triangles is discussed. Freshmen, three hours, first semester.

31. Higher Algebra. A course of selected topics in algebra, including the graphic representation of algebraic functions, inequalities, ratio, proportion and variation, complex numbers, logarithms, determinants, the study of quadratic equation in one variable, the cubic equation (Cardan's method), the biquadratic equation (Ferrari's method), and the approximate methods for the solution of numerical equations. Freshmen, two hours, first semester.

32. Analytical Geometry. Development of Cartesian and polar co-ordinate systems; equations of loci and plotting of the corresponding curves; special study of harmonic curves; the straight line; the circle; transforming of coordinates; the conic sections as a class, tangents, normals, and polars; properties of the parabola, ellipse, and hyperbola; interpretation of equations in three dimensions and in particular the straight line, the plane, and the central quadratic surfaces. Freshmen, five hours, second semester.

33. Differential and Integral Calculus. This course is conducted to serve the requirements of engineers. By means of a minimum number of fundamental formulas the student is instructed in the differentiation of all ordinary functions. Applications are made to the determination of maxima and minima in physical problems, to the determination of errors, and to problems in curve-tracing and curvature. Sophomores, three hours, both semesters.

34. Analytical and Applied Mechanics. The object of this course is to emphasize the principles fundamental in every branch of applied mechanics. The primary principles of analytical statics are treated, including a study of the composition and resolution of forces, application to rigid bodies, centers of gravity, centers of mass, friction, virtual work, flexible strings, funicular polygon, the catenary and loaded chords, and the theory of attraction. The analytical theory of kinetics is developed, and in particular are treated laws of motion, variable forces, constrained motion, resisting medium, central forces, impact, energy, work, dynamics of the steam engine, moments of inertia, rotary motion, the simple and the compound pendulum, and the equations of Lagrange, Hamilton, and Euler. Juniors, five hours, first semester.

35. Mechanical Drawing. The earlier exercises are designed to familiarize the student with the instruments and materials, giving him practice in line-work in both pencil and ink. Succeeding plates require the laying out by both accurate and approximate methods of regular curves used in more advanced work; standard sheets covering conventional sectioning for materials, representation of structural parts in elevation and section, and standards for bolts, threads

and pipes. The principles of projection of elementary geometrical figures to that of actual machine parts, lead finally to practical machine drawing, fully dimensioned. Freshmen, four hours, both semesters.

36. Descriptive Geometry. This is treated largely as a class-room subject, the object being to enable the student to form mental images of objects from various standpoints, before proceeding actually to depict them. Freshmen, two hours, both semesters.

37. Machine Drawing. A course that includes the preparation of dimensioned working sketches of actual machine details; the execution of detail and assembly working drawings from sketch; tracing and blueprinting; conventional representations of engineering materials; practice in reading drawings of unfamiliar machinery and the demonstration of ability to read by the rendering of free-hand perspective geometry to the reading of complicated drawings, and the preparation of illustrative detail sections and elevations; practice in the design of cams, gears, and other devices analyzed in the course in mechanism; development of the principles of correct expression without repetition or complication, and practice in economical preliminary "blocking out" of the work for subsequent detailed treatment. Sophomores, four hours, second semester.

38. Machine Design. A course in the class-room and the drafting-room, covering the calculation of strength and stress, in the design of machine parts; computation of engine details; relation of design to shop possibilities and shop practice. Juniors, six hours, first semester.

39. Mechanism. A class-room course, supplemented by drafting-room problems, in the kinematics of machinery, including the study of motions and their combinations, the forms of screws, gears, cams, link motions, escapements, and quick-return devices; velocity ratios, instantaneous centers, graphical representations of velocity and acceleration, trains of mechanism, toggle joints, straight line motions, pulley blocks, chain and belt drives, pulleys, and other standard types of mechanism. The course concludes with the assignment of specific problems in movement, to be solved independently by the student, by graphical and analytical methods. Juniors, two hours, second semester.

40. Vise Work. Practice in chipping castings and forgings of various materials, the filing of true surfaces, freehand filing, fit filing, scraping, drilling and tapping, pipe cutting and threading by hand and by machine, and the assembly of machine parts. Juniors, three hours, second semester.

41. Experimental Engineering. A course of lectures and elementary exercises introductory to the work of the mechanical laboratories. The methods of conducting various tests and experiments are described, and instruction is given in the general features of accurate experimentation, precision of measurement, calibration of instruments, analysis of errors, objects of specific tests, methods of noting data and compiling results, forms for reporting experiments, the methods for studying factors affecting efficiency, arrangement of apparatus, and the equipment necessary for various physical determinations. Sophomores, one hour, second semester.

42. Thermodynamics. The properties of gases; graphical representation; heat measurements; the mechanical equivalent of heat; formation of vapors at constant pressure; properties of steam; superheating; air compression. Fourth-year students, three hours, first semester.

43. Refrigeration. Thermodynamics of refrigeration, the Joule cycle; vapor compression systems; coefficient of performance; warming machines; wet and dry compression; absorption system; commercial requirements; packing-house, brewery, and ice-making processes; working fluids, ammonia, ether, air, carbon dioxide; compressor design; properties of brine; properties of saturated vapors used in refrigeration; commercial efficiencies; ratings; methods of testing plants. Fifth-year students in chemical engineering, one hour, first semester.

44. Testing Materials Laboratory. Tension tests on iron and steel; compression tests on wood, concrete, cast-iron, wrought iron and steel; effects of varying the proportions of sand, water and cement on the strength of mortar; tension tests on standard cement briquettes; cross-bending tests on wooden beams and I-beams; cross-breaking tests on standard cast-iron test-bars; tests of small iron and wood columns; and tests on reinforced concrete beams. Fourth-year students, three hours, second semester.

45. Hydraulic Laboratory. Test of a steam pump; test of a fire nozzle for coefficient of discharge; test of a weir to determine the coefficient under varying head; tests to find the coefficient of a water meter; experiments with a sharp-edged orifice; tests for efficiency and capacity of a Hancock ejector; tests to determine the lengths of straight pipe equal in resistance to globe and gate valves and pipe fittings; tests of a twelve-inch Doble water wheel; experimenting with a hydraulic ram; applications of various methods of calculation to the flow of water in both simple and compound pipe lines under constant head; the reaction of a water head; the reaction of a water jet; and the time to discharge a tank under a dropping head. Fifth-year students in chemical engineering, three hours, first semester.

46. Steam Engines. Actual behavior of steam in the cylinder; application of the temperature-entropy analysis; analysis of indicator diagrams, combined diagrams from multiple expansion engines. Hirn's analysis; proportions for compound engines, cylinder ratios, distribution of work and strains, drop, receivers, and reheating; the testing of steam engines, heat unit ratings; results of trials; commercial types; standard forms for power plant and mill applications. Fourth-year students, three hours, second semester.

47. Power Plants. The mechanical forms of prime motors and their auxiliaries; comparisons of gas and steam power plants; the questions of load factor and cost of fuel. A plant of each type is designed to suit a prescribed load curve. Fifth-year students, two hours, first semester; four hours, second semester.

48. Works Management. The principles of business organization; classification of industries based on ratio of cost of plant to annual productive power; influence of form of organization on engineering practice; aim and method of cost keeping; the use of curves in statistics; depreciation; labor problems, piece work, premium and bonus systems, employer's liability, trades unionism; distribution of fixed charges; economy of administration; engineering specifications and contracts; patents and patent law; the principles of accounting; corporation accounting; analysis of annual reports; apprenticeship; actual cost systems in foundry, forge-shop and machine-shop; modern tendencies in administrative engineering; the place of the technical graduate in the industrial organization. Fifth-year students, one hour, second semester.

49. Gas Power. Internal combustion engines; fuel gases, chemical and physical properties and calorific values; gas coals, natural gas, industrial gas; gas fuel in metallurgical operations; the gas producer, economizing auxiliaries; regulation of production; gas storage, the gas engine cycle; historical development of internal combustion engines, gasolene and oil engines; limitations of efficiency; temperature-entropy analysis; gas engine auxiliaries; applications and limitations of gas power; mechanisms for control of air, ignition, and regulation; recent patents; denatured alcohol for power; modern types of engines; problems in actual design; methods of cooling; valves and valve gears, rotative effort diagrams; reclaiming the waste heat of the exhaust gases; economical utilization of jacket water; actual tests of efficiency; special applications; the automobile; arrangement of cylinders, capacity, carburetors, transmission gears; the driving of electric generators; general economic considerations; influence of cost of fuel and first cost of plant on the choice of a prime motor; comparisons of reciprocating, turbine and gas power plants. Fifth-year students, two hours, first semester.

50. Mechanics and Heat. A thorough course in the fundamental principles of mechanics and heat; force, work, energy and power being brought to the attention of the student and differentiated from one another by means of many problems. Freshmen, two hours, both semesters.

51. Electricity and Magnetism. An introduction to the elementary principles of electricity and magnetism with a short description of some of their applications to commercial and industrial problems. Sophomores, three hours, first semester.

52. Sound and Light. A detailed study of the principles and phenomena of sound and light. Sophomores, three hours, second semester.

53. Laboratory Physics. A course involving the quantitative measurements of some of the more common physical constants conducted with particular view to supplementing the courses in Mechanics and Heat, Electricity and Magnetism, and Sound and Light. Sophomores, two hours, both semesters.

54. Electrical Measurements. A course demanding the precise determination of the common electrical and magnetic magnitudes, and involving the use of fundamental standards. Sophomores, five hours, second semester.

55. A progressive course is offered during the Freshman year in the fundamentals of athletics, German and Swedish gymnastics, anthropometry, swimming, folk-dancing, massgames, playground organization, personal hygiene, and ventilation. Freshmen, two hours, both semesters.

Discussion

Dr. Olsen:

Since Wednesday, when this course was presented to the members, it has been criticised because the time given to qualitative analysis is large. It is practically ten hours a week for one and a half years. I will say in this connection that I have followed the practice of many schools in giving such courses. The impression made in the first year on the student needs a great deal of strengthening in order,

so to speak, to become a part of the texture of his mind, and so pass into the subconscious part of his thinking capacity. You all undoubtedly realize that education is a process of converting ideas and facts from the conscious to the subconscious part of the mind, and only as we do things unconsciously do we do them easily, and that facility and certainty are characteristic of reflex action, and only considerable repetition, and a great deal of practice, will make what might be called an " expert "; the man who has become so grounded in it that it becomes second nature.

In the general study of the principles of the science and the study of the compounds of various elements, it has been found that it is better to pass on to qualitative analysis and devote a very considerable proportion of the time in that subject to going over these fundamental principles, and taking each element and studying it quite thoroughly, impressing on him the fact that the student is to use his knowledge in detecting the elements in these compounds; and I believe the ratio of one-third to two-thirds is a pretty good ratio; that is, about two-thirds of the time will be devoted to familiarizing the student with the elements to be detected, and the other one-third to be concerned specifically with what might be called " technical methods of analysis."

I notice that the book by Prof. Stieglitz, of Chicago University, who has devoted a good deal of his time to this subject, is published in two volumes, Nos. 1 and 2, being all theory of the subject, giving the student a general idea of the subject; and the other one-third is devoted to technical methods of separation and identification. So you may consider that the larger proportion of the time devoted to qualitative analysis, is really devoted to the study of the principles of inorganic chemistry, and the study of the compounds of metals and acids before they are to be separated.

Another criticism which came to me was that the time devoted to the subject of industrial chemistry was brief. In this course, four hours are given throughout the fourth year. Now in the first place, some other subjects might be considered industrial chemistry, such as Gas Engineering and Gas Power, Works Management, etc., but the time given to this subject was limited because, in the vote of this Institute on this question, the point was brought up very strongly by a great many who answered the questions or wrote letters explaining their views, that they did not believe that much time should be spent in the college or technical schools on strictly

factory methods; that the place to teach that was in the factory; that the things to be taught in the college were the fundamental principles of chemistry, physics and mathematics, to see that the student understood those general principles, and that the professors should not attempt to give technical practice; that this should be left for the factory; hence I took the middle ground and devoted a year to that subject of four hours a semester—two for lecture and two for laboratory.

The PRESIDENT:

The subject is open for discussion.

Prof. H. G. BYERS:

I feel very strongly that this course as prepared by Prof. Olsen ought not to reflect the feeling of the Institute, and I, at least, would be very unwilling to approve this course as an ideal course in chemical engineering.

I agree with Prof. Olsen on the point of factory methods, technical methods in general, and the part of it to be given extensively in college work, because there is no use in trying to conceal the fact that the university professor is a back number when it comes to industrial practice; he cannot help but be a back number, because I think the statement is true that there are something like 470 different slants of applied chemistry, that is, lines in which chemistry comes into practice industrially. Now if the university man is going to keep up in his university business, he cannot keep up with 470 different groups of men giving special attention to their different lines of business: therefore we are behind the times, and technically a book which is published is behind the times when it is published, and getting more and more behind every day. We cannot do that and do it well, but we can and we ought to give the fundamental principles of chemistry, and grind them in and keep grinding them in, and then when the student is prepared to develop a given line of activity, he can make use of these fundamental principles and get further and get there more quickly than the man who has not those fundamentals.

Now taking it as the purpose of the engineering course to give the student the fundamental principles of a chemical education, with chemical engineering as a base, there are a lot of arrangements in this course that ought not to be there. In the first place, Prof. Olsen has mentioned the use of qualitative analysis as a means of teaching the principles of chemistry. He cannot do much in that

way, in my opinion. Chemistry is a broader thing than qualitative analysis, and if the teacher is going to go outside of qualitative analysis for his illustrative principles, why not do it concisely and call it general chemistry? The amount of general chemistry in this course is entirely inadequate for the purpose, and the proper amount of general chemistry cannot, in my opinion, be furnished by qualitative analysis. The amount of time for qualitative analysis is, in my judgment, out of all proportion to its importance from the technical standpoint, the standpoint of general principles of chemistry, and the standpoint of the time the student has to devote to preparation.

Prof. Olsen has mentioned Prof. Stieglitz' book. To those who are familiar with Prof. Stieglitz' work, it is known that only a small proportion of that book is intended for undergraduate work. It is intended as a post-graduate work for the preparation of teachers.

Another feature that is extremely bad, from my standpoint, is the poor provision for the study of organic chemistry. There is no single phase of chemistry that is more important than organic chemistry, especially for understanding general chemistry, for general analysis and qualitative analysis, but its importance for the sake of other phases of chemistry is underestimated, in my opinion, because, strangely enough, if you will study the history of chemistry you will find that very largely the development of inorganic chemistry came first, through the development of the more complex subjects, then back to the understanding of the simple things. There is no organic chemistry in this course until the senior year. At the same time, while the student is beginning his organic chemistry, he is supposed to be having physical chemistry, and then thermo chemistry. I think the study of organic chemistry should begin not later than the junior year at any rate. The fourth year in this course which, at least for our arrangement of engineering instruction, is the closing point, is almost solidly chemistry. It is very largely chemistry, that is, the chemistry is bunched in the senior year. Then when you come to the fifth year, the postgraduate year, there is no chemistry to speak of except the thesis, and that is bunching the engineering in the fifth year. Personally I do not think that is a good way to plan the course. Those are the main criticisms I have from the chemical end.

Then I have a criticism or two from the other side of the subject. There, of course, I am getting into a point where I am not so familiar,

but still I know something about it. I know our Professors of Physics would rebel if we undertook to give electrical terms to students who had not had any course in electricity, and in the second semester of the sophomore year there is a course of five hours a week in Electrical Measurements. (Electricity and Magnetism, I do not find that in looking it over.) So if we had a course in Electricity and Magnetism, then Electrical Measurements would come in all right. Now the twin sister of chemistry is physics. If anybody can find where there is a natural division between chemistry and physics, I do not know who he is or where the division is. Physics and chemistry are one in spirit and in their importance to the chemical engineer. It seems to me this course is weak from the standpoint of the fundamental principles of physics, not from the amount of physics that is in there because, of course, a lot of the work—steam engineering, experimental engineering, electrical engineering, and all that sort of thing, is essentially physics, but the same criticism that applies to a lack of general chemistry applies, in my mind, to the corresponding lack of attention to general physics, the fundamentals of physics.

I am frank to say Prof. Olsen is an old friend of mine, but I do not like that course.

Prof. OLSEN:

I wonder if you have thought, Prof. Byers, that I said that general chemistry and physics are essential to entry upon this course. The student should have spent at least a year on general physics and chemistry before he comes to this course.

Prof. BYERS:

My understanding of teachers of chemistry in the high school is that they do not, but they ought to adopt the principle which Prof. Smith lays down; that is this: that the high school chemistry is a general chemistry, viewing the field as it is; while the college general chemistry is a course which views it as it is from the standpoint of how it got there; and that is the important point, and the course in the high school will not take the place of that.

Prof. J. H. JAMES:

It seems to me that in all this discussion as to the length of the chemical engineering course, the subjects taught, etc., we are losing sight of the fact that the young man entering the chemical industries

as an engineer or operating chemist, will have a line of work of different character from that of the research chemist.

In the laboratory of any chemical plant there are always two lines of work carried on, routine analytical work for factory control, and research. The analytical laboratory in these plants is really a sort of apprentice school for the young chemist or chemical engineer. If he has ambition, he certainly does not want to settle down in life as an analytical chemist, so his work in the analytical laboratory will always be for a longer or shorter "trying out" period, before he takes up the work out in the plant. The analytical chemistry given in almost any of our technical schools is sufficient preparation for this part of the young chemical engineer's work, and it should be taught with the idea that it is not an end but the means to an end.

When our chemical engineer has served his laboratory apprenticeship, his work in the plant will be of such a character, that we would have been doing him a great injustice to have put him through a course in school of the same character as that outlined for the man who expects to take up chemical research. The chemical engineer will be putting into operation on a large scale a process, the details and conditions of which were worked out by the research chemist. All the problems connected with the process, however, have not been solved; these are the problems confronting the chemical engineer, who must carry out on a large scale the operations indicated by the research chemist, such as the handling of thousands of gallons instead of cubic centimeters of solution, and hundreds or thousands of pounds of solid materials, instead of grams. He must figure out methods of rapid solution, of rapid filtration, of rapid evaporation, all applicable to these large scale operations.

It is obvious that the training suitable for the chemical engineer should be essentially different from that of the research chemist. The five- or six-year course advocated by some members of the Institute really allows for enough time to combine research and engineering training. Admitting that such a course would be ideal for any young man entering the chemical field, we are confronted with the fact that the great majority of students come from families whose circumstances do not permit their sons to take a five- or six-years course. In such cases the young man must choose within pretty narrow limits the technical field in which to take up work, and prepare himself in the least possible time. The problem before the educator then, is to arrange the course in chemical engineering so that the

student will receive a thorough training in the fundamentals of science and in the application of these fundamentals to the solution of technical problems, in a time somewhat commensurate with what the average young man can afford.

This time, for the course in chemical engineering, can certainly be limited to four years, provided the institution has a faculty of sufficient numbers to allow for the arrangement of special minor courses in the allied engineering subjects. This I have discussed at some length in the paper on the Four-Year Course in Chemical Engineering, read at the Chicago meeting of the Institute, in June, 1911.

As to the best course for the student who intends to become a research chemist, it seems to me that we can hardly improve on the regular Ph.D. work offered by all our large universities. In cases where the matter of finances will not permit the student to finish a four-year B.S. or A.B. course with at least three years' post graduate work in addition, I think he should take a four-year course in chemistry in a good technical school, not taking up any of the engineering work offered in the course in chemical engineering.

Another criticism from the engineering side: Prof. Olsen seems to have worked in, in one way and another, about all the engineering subjects the chemical engineer would need, with one exception. I would suggest that while we have the student who is studying to be a chemical engineer studying all these general subjects in the chemical engineering department, he takes the elements of electrical engineering in the electrical engineering department; hydraulics, of civil engineering, in the civil engineering department, and so on, there is no special schedule here which brings to the student the method of applying all those things which he has learned in these various engineering lines under one head. In other words, where would your chemical engineer have some practice in laying out a plant; in writing specifications for the machinery for the plant; for utilizing all the knowledge which he has gained in the several departments under one general head? I would suggest a general head called "chemical engineering," which brings together all these things in a clear, concise manner, for the student, and in addition, gives a course in engineering, from the chemical engineering standpoint, which he would not get otherwise. There is a field there which the student taking this course cannot have covered because of the very nature of the case. The men in each line are specialists in those

lines and the man who is outlining a chemical engineering course should bring together all these subjects to make a practical application of them. I believe that we should have the course arranged so as to give the student some idea of the use he is to make of his electrical engineering, mechanical engineering and his chemistry. I would eliminate some of the industrial chemistry as it is ordinarily taught. I agree with Prof. Olsen on that and the majority of the members of the Institute. It is a farce to teach industrial chemistry as it has been taught in our American institutions. What we want is the fundamentals of chemical engineering and the fundamentals of the other subjects, so that the chemical engineer can go out and apply his engineering knowledge. As I said in our Chicago meeting, I believe the course cannot be too broad, because the chemical engineer comes in touch with physics and chemistry at so many points. I have my four-year course arranged according to what I believe is the relative importance of the subjects, and I believe it is a better course than this. (Laughter.)

Mr. WHEELER:

When I finished my course, and began work in a factory, the hardest portion for me to take hold of was the qualitative analysis. I think qualitative and quantitative analysis are a good thing to teach the student together, so that he can take hold when he gets out into practical work. His first work will probably be in the laboratory, and his progress will be through that channel, and if he is not thoroughly familiar with laboratory practice he is almost like a ship without a starting point; he is thrown in the middle of the ocean, with a capacity to go somewhere, but without having some place to begin; so that I would emphasize that quantitative analysis and qualitative analysis can be used as a tool to teach the general chemist, so that he will have a proper knowledge of the starting point, therefore I think it is very valuable.

Prof. WITHROW:

I think I can agree very readily, when I look upon the thread of gold that runs through this whole thing, with what has been said and the great emphasis that has been placed upon fundamentals. I think the more we get out of practice, the more we always hark back to that one thing; fundamentals are all important things. We want, of course, a little in addition to the other things, but not too much. That is one of the points I want to emphasize.

With reference to the point made of physics, I am not so certain as to that. I notice that there are two hours in Mechanics and Heat in the first and second semester of the first year; five hours in Physics throughout the second year, and so on. Of course, the chemical engineer is not as much interested in physics as he is in chemistry, the fundamental science of chemical engineering. I am not in favor of so many hours devoted to the thesis. If a man was going to try for the Master's degree it might be done, but I do not think that fifteen hours a semester devoted to the thesis for a chemical engineer is time well spent. I think with the majority of chemical engineering students it will be a bad thing. In my case, if I had to handle 28 students for fifteen hours in thesis, I would go into the grave very soon. It would be a very bad job to have 28 students, to give each of them a topic and keep them busy.

Prof. OLSEN:

You have too many. You should get another man or two to handle so many students.

Prof. JAMES:

I would like to ask Dr. Olsen what is proposed to be given under the topic "Experimental Engineering" in the second semester, sophomore year.

Prof. OLSEN:

I will read the description of that course: "A course of lectures and elementary exercises introductory to the work of mechanical laboratories. The methods of conducting various tests and experiments are described, objects of specific tests, etc."

The PRESIDENT:

Before Dr. Olsen takes up the subject again I would like to have a few words myself, for the particular reason that our training for chemical engineers has been a heresy when compared to the program outlined by Dr. Olsen. My training was entirely theoretical. My whole surroundings, laboratory, etc., were absolutely theoretical, both in organic chemistry and in inorganic chemistry. The fact that astonished me most of all was to find in this country so many chemists who studied chemistry and feel very shaky in organic chemistry. It gives me about the same impression as to find a mechanical engineer who is threatening to study steam engineering.

Now at that time we received theoretical training, but we could

not study chemistry alone. Before I could take my special degree in chemistry I was compelled to take a degree in the general metal sciences. I had to graduate in geology, mineralogy, and so on, which gave me excellent training for the field of general engineering chemistry, and then I took a position which was open, although I hated it very much, but we needed the money and, *nolens volens*, I got turned into a chemical engineer, which meant converting my time and knowledge into the most dollars and cents. (Laughter.)

I have always jumped from one subject to another in extreme directions. My Professor could not understand it, but I can, because I concentrated my attention on one subject so that I got heartily sick of it, and jumped to another subject which had no connection with it. I did what everybody ought to do. I studied the matter thoroughly, then when I again got back into organic chemistry, before I knew it I was in electro chemistry. When I studied it, electro chemistry did not exist. Some few people knew the name twenty-five years ago, but it did not exist. Dynamos were just at their beginning. It was as interesting to see a dynamo as it is now to see a flying machine. When dynamos and motors and transformers came in I did not have very much trouble to get in with them but I could have picked out some flaws in the general practicability of the scheme. I really believed there was no advantage in them.

This course in chemical engineering as proposed by Dr. Olsen is about like the conditions which existed at the university where I studied, in the matter of attention to details of chemical engineering. That was about the program, and I can give you the history of that program. They turned out people who went through just that class of training and who came out with a lot of knowledge but tremendously little judgment. They made poor engineers and still poorer chemists. In fact, I cannot think of a single man who afterwards really amounted to something. They were repudiated by engineers and still more so by chemists, still they had the diplomas. Some of these fellows had to make their living by teaching in the technologic schools and universities, but in practical lines they did not succeed. This country, gentlemen, is affected like many other countries, by too many professional men. Too many people are willing to talk about success, but they are not so able to do things for themselves. We have too many physicians and lawyers, and too many poor chemical engineers. You are educating yourself, and I am educating

myself, and my gracious, what I have learned in the last year makes me think that what I learned in the last twenty years is lost. It reminds me of a German friend I used to have who was studying all the principal streets in Europe. He knew all the streets in the principal cities of Europe, and he knew all the streets in Constantinople and other cities of the East, but one day he visited me in Yonkers and they had to send a man along with him so that he would not miss the trail in attempting to get out to my house. So after all, I can give a man the four principal problems of life which he will have and he will not be prepared for it, because so much is left out of this course, and he would be utterly unfitted for it. Somehow I cannot feel very enthusiastic about this course. I very much agree with what Prof. James Withrow and Byers have said. I am perhaps somewhat biased. In all my experience with teachers, and in the experiences I have had as an employer, with regard to chemical education I have met many freaks in my life, people that knew so much. There are too many men who know how to explain things, and I feel like telling them that all the knowledge they have is of very little use to me if they do not use it at the proper time; and I challenge the man who knows everything to know as much as my library knows. My library is just as useless if I do not pick out the right book at the right time. I find the same with all those beautiful programs. You find the people who write these books did not have the knowledge; they had good judgment, and good judgment helped them. They will be like the man who is dining out at one and two o'clock in the morning who will have a fine case of dyspepsia the next day.

Now Dr. Olsen has a chance to get back at us.

Prof. Olsen:

I have enjoyed this discussion very much, and if I was the cause of bringing out all of these statements, I congratulate myself that I have done a good thing. I did not suppose for one moment that this course was perfect or anything like it. I put it together mainly to see how it would work. That is, how the course would look which was prepared in accordance with the vote of this Institute.

Dr. Baekeland has, using an ordinary expression, " roasted it." He has roasted it brown. I feel that in doing so he has roasted the Institute, because I fixed it up in accordance with the vote of the Institute, and when it comes to Gas Works, Gas Management,

Refrigeration, Hydraulic Laboratory, and Engineering Economics, etc., they were all voted on specifically, and there is a majority of the Institute who voted in favor of them.

Now I am quite ready to come back to first principles, and am quite ready to discuss the matter on the basis that Dr. Baekeland has brought forth. I am very conscious of the fact that I myself, Dr. Baekeland, and many of the older generation went through college and received a general education, considerable science, mathematics, physics and chemistry, and then we devoted three or four years to the study of chemistry as postgraduate work, and received a Doctor's degree; and we did not take all of these subjects, it is true. We had the chemistry pounded into us, morning, noon and night. We lived in the laboratory; we did nothing but work in chemistry, and with chemistry almost all the time, and I did not stop summers either; I kept at it pretty nearly 365 days in the year, taking out only a few holidays. And of course, if we are going to come back to this fundamental question, we must ask: are we wrong in calling for these specialized subjects?

I am inclined to think, however, that a great many of the failures which are noted to-day are probably due, not so much to education as to the individuality of the men who are getting the education. I have no doubt if we could go back and find a list of the men who took up this work at the time Dr. Baekeland did, there may be many of his friends who have not attained to the eminence and carried out the successful work that he has done, nor have solved the three, four, five or six large, important problems which he has solved. There is a great deal in personality. While one man may fail, another man will succeed under similar conditions. I myself have considerable hesitation with ragard to the tendency of education to-day, and have a great deal of misgiving that perhaps we are putting in too many applied subjects. I am inclined to think we are, in many cases, in the condition of my friend who is a very nice man in every respect; he is a gentleman and a scholar; a most delightful neighbor; but he has a couple of sons who are just the opposite. They will throw mudballs at your windows, will do all kinds of tricks around your house. The principal of the school which one of them attends says my friend's son is the worst specimen of a young fellow that he has ever dealt with. The father said to me one day on the street: " I was raised in a very strict way. My father and mother insisted on my toeing the line every time. They would not let me have my

way," but, he says, "my boys are not going to have that kind of a youth; they are going to take life easy and do pretty much as they please." Now that father thought possibly of his youth, when his father used the strap and said, "Son, behave yourself now, or you will hear from me," and possibly as it was at that time with that father, so it may be with the boys in the colleges who are so intensely interested in the applications and want to take so many of these industrial courses which appeal to them so much; maybe we ought to restrain them; we ought to say to them, "You stick to the fundamentals of chemistry; you live in the fundamentals of chemistry for three or four years; let applications wait until you get out of college."

Now all this argument leads me to believe that a four-years' course, as Prof. James indicates, is not correct. I take direct issue with Prof. James on this. I look at the list of our members, and find a large number of Doctors of Philosophy. That means it took seven years to get a degree. Seven years of study of fundamentals has made the successful men whom we have honored by election to this Institute, so that speaks against a four-years' course, if we are going to crowd physics, chemistry, etc., into the four years.

With reference to inorganic chemistry being brief, I am also quite willing to admit that it might be more desirable to list inorganic chemistry as three hours a week throughout the course, and cut down the time in qualitative analysis. That is entirely feasible. I do not believe the principles of qualitative analysis can be taught without teaching some of the principles of general chemistry and of physical chemistry. I would not give qualitative analysis without them.

Chemical engineering might be given in this course under the subject of industrial chemistry.

With regard to the thesis, I personally feel that we cannot make very good chemists unless the number of students to a single professor is very small, and if a man should ever attempt to have a class of 28 at thesis, even if he gives his entire time to the 28 students, I do not believe he would succeed. If that is the condition in a particular school, I would vote "aye" to cutting out thesis entirely. The best thing a man can do is to have a half dozen students working with him on research problems. I think when there is time and it can be done in that way, there is a great deal of advantage in the thesis. I think when you show a student how to develop an unknown prop-

osition, it is quite valuable if he has the assistance of his professor when he is carrying out the work, but under other conditions it is probably of no advantage.

Dr. F. W. Frerichs:

I do not like to say anything about this chemical engineering course. I have never been a teacher, as many of you have been, and I have never attended a college or technical school such as you have here in America. Your colleges resemble pretty closely the polytechnic schools in Germany, and chemistry was not taught at the polytechnic schools in my time. That was developed possibly within the last ten years, when it was found that chemical engineering was becoming a science and that chemical engineers were wanted for the industries.

In my time we studied pure chemistry at the universities. In the last ten years the polytechnic schools have taken up more chemistry than we used to get in former years, and at the same time they have the opportunity of teaching the engineering sciences. They have inaugurated a degree which they call "Doctor of Engineering." The degree of Doctor of Engineering is given now in Germany to chemical engineers who have taken an advanced course in chemistry and engineering at the same time.

Now it might be of interest to you to know in what way I acquired my knowledge, and in what respect I found myself deficient in certain studies which would have given me great advantage and would have saved perhaps four or five years of my career.

(Dr. Frerichs then gave a very interesting account of his personal experiences in acquiring an education, recounting the hardships which he encountered in his struggles to secure a technical education; his early practical experiences in Germany and his later experiences after coming to this country, including his experiments in the matter of attempting to manufacture chloroform from alcohol, and his later success as a manufacturing chemist.)

I believe I could have become successful at an earlier time if I had studied drawing, which I did not do and therefore was not able to make my own drawings. I had to make rough sketches of my improvements in manufacturing operations, which were often misunderstood, and I realized, by the lack of this accomplishment, that I lost time which I believe will aggregate three or four years in my career.

I therefore advocate, to such an extent, that students who want to make the very best use of their time and want to make themselves fit for efficient work, should acquire these accomplishments, which I will enumerate as follows: first, drawing; then the fundamentals of engineering, mechanics and hydraulics, as they are enumerated in this pamphlet. How much you want to give them I believe is better judged by the teachers who have to handle the boys at such an age as they come from the high schools. I have had no experience in this respect, but I should think that if a young man has assimilated the fundamentals of engineering, he also should be instructed in the application of them. That is what I missed in the courses given at the universities in Germany—the application of engineering, upon drawing of chemical apparatus and upon the construction of apparatus and machinery specially used in chemical works. That would, in my opinion, be of special advantage and would make the chemist a chemical engineer.

In addition, he ought to have training in making industrial research, of which I have given you a few instances in papers presented to you.

Dr. F. G. Wiechmann:

I am much interested in the suggested course in Chemical Engineering, and wish to suggest some changes in that course, which, in my opinion, would serve to strengthen the same.

In the first place—of course this is only a trivial matter—it seems to me it might be more consistent to designate the five years as: First year, second year, third year, fourth year, fifth year, instead of denoting the first three years of the course as the freshman, sophomore and junior years respectively, and calling the remaining the fourth and fifth years respectively.

Freshman Year

First Semester. Here I believe that Fiction and the Drama, two hours a week, might well be omitted, and the time so gained devoted to additional work in some other subject taken up during that semester. My own preference would be to give this time to a Review of Elementary Inorganic Chemistry.

Sophomore Year

As the student will already have had a full year of Qualitative Analysis, I would suggest that in the first semester of the sophomore year the study of Quantitative Analysis be substituted for that of Qualitative Analysis; that the two hours devoted in the first semester to European History be given to American History.

In the second semester of the Sophomore Year I would cut out Mineralogy and continue in its stead Quantitative Analysis.

Junior Year

In the first semester I would cut out the Quantitative Analysis, substituting for that seven hours of Mineralogy (two Lecture, five Laboratory), and give ten hours to Industrial Chemistry (Lecture three, Laboratory seven).

In the second semester I would again give ten hours to Industrial Chemistry (Lecture three, Laboratory seven), and ten hours to a Review of Quantitative Analysis (three Lecture, seven Laboratory).

Fourth Year

In the first semester I would cut down Organic Chemistry to thirteen hours a week (three Lecture, ten Laboratory), and give instead two hours of Spanish.

In the second semester I would cut down Organic Chemistry to fourteen hours a week (two Lecture, twelve Laboratory), and add three hours of Spanish per week.

Fifth Year

In the first semester I would devote only eleven hours to the Thesis, and give instead two hours instruction in First Aid to the Injured.

Dr. Edward Hart:

I have been teaching chemistry for thirty-six years and as for most of this time I have also been practicing chemical engineering, I have naturally given some thought to the preparation of students in chemistry for this work. For various reasons we cannot do many things we would like to do and I cannot claim either that my course

in chemistry was or is the best possible, or that my students, eight or ten of whom are members of this Institute, were prepared in the best way.

The discussion may be divided as follows:

First, how many years are needed?

Second, what shall we teach?

Third, how shall we teach it?

(1) I am very sorry to see the members as a rule in favor of five-year courses. This adds another to the unproductive years of a man's life and will often prove the last straw in breaking the financial back of the already long-suffering paterfamilias.

As life is a continuous education, it is not necessary that one shall learn *all* there is to learn in college. Four years, I am convinced, can be made to give a young man with the needful equipment of brain, properly brought up and with proper training to enter college, a sufficient knowledge of chemistry, physics and engineering to take his place in a work's laboratory and there learn the practice.

(2) On Prof. Olsen's proposed course I would comment as follows:

(*a*) Fiction and the Drama, Rhetoric and Composition and Modern English Prose and Composition ought to be sufficiently understood before the boys come to college. I would substitute a course of two hours a week in How to Write Letters. Chemists do not worry about Fiction and the Drama, but they do write letters and many of them write very poor ones. It is easier to teach English in practical fashion.

(*b*) Most high school boys don't know elementary inorganic chemistry well enough. I begin at the beginning. If the boys think they know it we examine them. They are usually convinced before the examination is over that they do not.

(*c*) Prof. Olsen's course, in my opinion, contains too much Qualitative Analysis. If he were obliged to do so, as we are, he would find it possible to give a sufficient course in half the time. It is necessary to divide the men into smaller squads to do this.

(*d*) I would cut out types of English Literature and European History.

(*e*) Too much time is assigned to Blowpipe Analysis. This can be taught with the Qualitative Analysis and Mineralogy.

(*f*) Where is Geology taught in Prof. Olsen's course and especially Economic Geology?

(*g*) I would cut out Economics unless that means Business System, which ought to take its place.

(*h*) French should come earlier and special attention in this and German should be given to readings in chemical subjects so that they may be used as *sharp* tools later on.

(*i*) Physical and Thermo Chemistry can be taught in half the time assigned.

(*k*) Too much time is assigned to Organic Chemistry. It is not necessary to learn the whole of organic chemistry.

(*l*) A good many of the Engineering subjects specified should be cut out and combined as Chemical Engineering. If taught with other classes of men, proper attention cannot be paid to the needs of chemical engineers and much time is wasted.

(*m*) Where is Assaying in this course?

(*n*) I would cut down the time given to Industrial Chemistry.

(*o*) The course in Water Analysis should include instruction in microscopical technique and elementary bacteriology.

(*p*) I think more shop work would be advisable.

(3) (*a*) I believe in going at a subject in the laboratory and reducing the lectures to a minimum, devoted mainly to explanations. Every class should be quizzed continually and the class should, for quiz work, not exceed 15. Half hour quizzes are best.

(*b*) Actual practice should be kept in view constantly and all the work should, without neglecting theory, have a practical trend. Unless this is done, the boys will lose interest. As an example, I will cite our course in Organic Chemistry: The first portion of time is devoted to distilling wood and separating the constituents of the distillate and to distilling crude petroleum. After the practice is familiar, the theory is studied. The boys are intensely interested and we get far better results.

INDUSTRIAL CHEMICAL CALCULATIONS

By JOSEPH W. RICHARDS

Read at the Chicago Meeting, June 23, 1911

INDUSTRIAL operations invariably develop through the qualitative stage before reaching the quantitative. The first achievement of industry is to do a thing, the last perfection is to do it with the greatest economy of time, material and effort. The beginnings of chemical industry were invariably merely descriptive, qualitative; the finest results of modern chemical engineering deal with exact quantities and the highest utilization of the materials and forces used. This last stage is only to be reached by a careful study and thorough mastery of the quantitative side of each process, of the chemical, physical and mechanical principles brought into play, and by continual comparison of the results attained with the calculated theoretically attainable.

In chemical instruction the quantitative side of chemical reactions is often quite extensively dwelt upon, and such books as So-and-So's "Chemical Arithmetic" or "Chemical Problems" are very good as far as they go. For the proper purposes and requirements of the chemical engineer, however, engaged as he is in the continual improvement of chemical processes, these books do not go far enough. Besides chemical arithmetic we need chemical mensuration, chemical analytics, chemical calculus; in short, all the aid and assistance which mathematical physics and chemistry can furnish to throw light on the exact quantitative side of applied chemical operations.

The chemist is concerned quite as much with molecules and molecular phenomena as with atoms and chemical reactions, and therefore applied chemistry is quite as much applied physics and applied mechanics as it is anything else.

Constants of Nature

The foundation of the chemical engineer's quantitative work must be a proper knowledge and just appreciation of the constants of nature, including the manner in which they have been determined, the limitations upon their accuracy, the conditions under which they are valid, and what they really mean and express. This is a most necessary part of the scholarly equipment of the chemical engineer, and one in which many are woefully lacking. It is in the school or college, under the wise instruction of men who know these things as they know their A, B, C's, that the chemist has the best chance to get correct fundamental ideas of these quantities and their nature. The writer may be wrong, but he has a conviction that time spent on learning these elementary and fundamental ideas is the best-spent time in a chemical course, that no amount of subsequent study in other directions can atone for any neglect of these fundamentals, and that, once equipped with the proper mastery of these fundamentals, the fortunate student is ready to pass on to any work which there is to accomplish, and to master it in like fashion.

What the writer means regarding these constants of nature is not merely to know them, as by name, number or memory, but to know them so intelligently as to be able to use them as a machinist uses his rule, a carpenter his square, or a blacksmith his hammer. To know them so as to use them as tools, as instruments of which he is master, as a master-builder uses his materials of construction. To attain such mastery of the natural constants is probably the largest part of a scientific education, and to utilize them skillfully to useful ends is the greatest achievement of the technologist.

If a student can take Landolt and Bornstein's Tabellen, let us say, and going through it page by page can thoroughly understand what the constants therein given are, and all about them, the theoretical or quantitative side of his education may be regarded as reasonably complete.

If asked to mention the constants useful in applied chemistry, the following would be an outline of their classification:

Physics. Metric system. Time; Velocity; Gravitation; Energy, work; Moduli of elasticity; Moduli of rigidity; Strength of materials; Hardness; Friction of solids, liquids, gases; Density of solids, liquids, gases; Viscosity; Surface tension; Tensions of gases and vapors; Volumes and pressures; Heat units; Temperatures; Coefficients of expan-

sion; Melting-points; Boiling-points; Critical constants; Specific heats of solids, liquids, gases; Heats of fusion, vaporization, dissociation; Change of specific heats with temperature; Thermal conductivity; Thermal resistivity; Heat radiation; Light units and standards; Indices of refraction; Refractivity; Absorption coefficient; Refracting power; Emmissive power; Electrical units and standards; Conductivity, change with temperature; Resistivity, change with temperature; Thermo-electric power; Constants of Peltier, Hall and Thomson effects; Specific inductive capacities; Dielectric strength; Magnetic permeability; Absolute electric charge; Rate of radioactive transformation; Heat of radioactive transformation; Velocity of sound.

Chemistry. Atomic weights, chemical equivalents; Valencies; Solubilities; Rate of solution; Contraction on dissolving or mixing; Diffusion constants of substances in solution; Diffusion constants of gases and vapors; Velocity constants of chemical reactions; Dissociation pressures; Equilibrium constants; Transition temperatures; Osmotic pressures; Vapor pressures of solutions; Electrochemical equivalents; Conductivities of electrolytes; Equivalent and molecular conductivity; (So-called) Ionization constants; Heats of solution; Heats of dilution; Heats of formation; Heats of combustion; Heats of hydration; Heats of neutralization; Heats of allotropic transformation; Calorific powers.

Mechanical and Electrical Equivalents of Heat Energy

Assuming a working knowledge of the above constants, and also mathematical ability extending to and including integral calculus, the chemical engineer should, to attain his full function, apply his knowledge to the quantitative study of industrial chemistry. The field before such an one is amazingly large, varied and attractive, it offers rich rewards to the proper man, it offers scope and opportunity for the most intense application of scientific method and calculation.

Following is a catalogue, certainly incomplete but nevertheless suggestive, of the many topics which are amenable to and embraced within the scope of industrial chemical calculations:

Generation of Heat. Detailed study of combustion, using analyses of fuel, air and chimney gases; efficiency of utilization of the fuel, of application of the heat; effect of pre-heating fuel or air.

Utilization of Heat. Rate of heat absorption by cold bodies, rate of heating up, rate of heat transfer through walls of retorts, muffles, etc.; recuperation of waste heat; regenerative utilization of waste heat; pre-heating charge, raising steam, heating blast or producing chimney-draft by waste heat.

Losses of Heat. By waste gases, by conduction through the walls, by radiation, chimney losses.

Coke and Charcoal. Heat required for charring, volume and utilization of waste gases, loss of output by combustion.

Artificial Gases. Running of producers, function of steam with air-blast, amount of radiation from producer, heat in hot gases, distillation products in the gas; thermo-chemistry of water-gas production; chemical equilibrium in the gas-producer at different temperatures, velocity of gas current and velocity of reactions.

Chimney Draft. Mechanism; variation with size of chimney and temperature of gases; efficiency.

Air Blast. Generation, power required, coefficient of delivery; heating of same by compression.

Hot Blast. Principles of heating air; recuperation (continuous) by parallel currents, opposed currents; regeneration, efficiency of regenerators, friction therein, proper design, proper working.

Dried Blast. Principles of refrigerating air; tension of aqueous vapor, dew point, thermodynamics of condensation or solidification; absorption of moisture by liquids or solutions, tension of water vapor over solutions, work of reconcentrating or dehydrating solutions.

Enriched Air-blast. Selective solubility of oxygen and nitrogen; methodic washing; differential evaporation of liquid air; production of liquid air; effect of enriched air on accelerating combustion, or other chemical reactions.

Washing of Gases. Absorption of gases by solutions, wetting of dust, diminishing surface tension, velocity of impingement.

Settlement of Dust. Carrying power of air currents, effect of frictional surfaces, electrostatic flocculation; bag filtration, surface and pressure necessary; air separators, sieving, sizing, flotation in air or other liquids; principles involved.

Percolation and Leaching. Rate of percolation, percentage of voids in material, effect of surface tension, use of pressure or suction, thickness of material most profitable to leach.

Settlement of Slimes and Precipitates. Rate of settlement,

carrying power of currents, influence of size of particles and viscosity of medium; non-settling solids, colloids and deflocculated materials, size of particles.

Agitation and Stirring. Velocities required to keep solids in suspension, power required, frictional resistances.

Crushing and Grinding. Power required for breaking and reducing to fine powder, mechanical principles involved.

Evaporation of Solutions. Work required to evaporate dilute solutions, strong solutions, expelling water of crystallization, complete dehydration; influence of gaseous pressure and currents in rate of evaporation and work required; evaporation by hot gases alone; vacuum pans; effect of partial pressures.

Fractional Distillation. Conditions for and work required.

Condensation of Vapors. Surface required; heat to be radiated; temperature limits.

Drying Ovens. Drying by hot gases; vacuum drying.

Solution of Gases in Liquids. Methodic absorption, maximum absorption point, saturation, evaporation of solute.

Hydraulics. Principles of flow of liquids through tubes, through orifices; flow of thick liquids and pulps; flow of gases through flues, around bends, through nozzles. Measurement of velocity of fluid flow; Pitot tubes, Venturi meters, anemometers.

Chemical Equilibrium. Decomposition of solids, dissociation, constant of dissociation, relation between decomposition pressures, temperature and heat of dissociation; rate of reaction; gaseous equilibrium; effect of catalysers; mass action; regulation of temperature by rate of reaction; reduction by gaseous agents. Application of above principles to specific cases, as follows: Producer Gas, Reduction of Oxides, Contact Sulphuric Acid, Fixation of Atmospheric Nitrogen.

Thermochemistry. Heat of reactions at other than the ordinary temperature, and with reacting bodies or products in various physical states. Heat to be supplied at the reaction temperature. Thermochemistry of high temperatures.

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PARTINGTON: Higher Mathematics for Chemical Students.
JÜPTNER: Heat Energy and Fuels.
QUENEAU: Industrial Furnaces.
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THE PRACTICAL VALUE OF THE DETERMINATION OF BRITISH THERMAL UNITS IN TESTING ANTHRACITE COAL

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THIS paper and the conclusions sought to be established are applicable only to anthracite coal.

The City of Greater New York embraces an area that may be roughly outlined as half a circle, having a diameter of 35 miles, extending from Tottenville, S. I., to the boundary line between the Borough of the Bronx and Mt. Vernon. A large percentage of this area is covered by the water of the East River and Upper Bay. While means of communication are admirable, they embrace tunnels, bridges, and ferries, that consume a great amount of time in their use.

The deliveries of anthracite for the use of the City of New York, including the municipal ferries, bridges, public buildings and water supply, are made at about 1200 stations. The quantities delivered at these stations vary from one ton to the contents of a barge of several hundred tons.

To test the quality of the coal delivered at these stations, requires that samples be made and gathered at one or several centers, where the tests of quality may be made.

It is assumed for the purpose of illustrating this paper that the samples are properly taken, as the samples used were all taken by one person. As an economic question the gathering of samples by competent persons over such a vast area is a serious problem. The samples gathered were sorted by screens as to sizes and the coal that passed each screen was carefully weighed and the percentages determined. These masses were again mixed and sorted by hand and the amount of bone and slate present weighed separately. The per-

centages of bone and slate are very important determinations. They indicate in a measure, when considered together with the results of analysis, whether the coal is poor in quality or whether a good coal, either through carelessness or purposely, contains an excessive amount of slate.

The whole of the sample was then crushed and pulverized in a ball mill, not to a powder, but to a finely granular condition, the grains resembling in size grains of rifle powder.

This is an important consideration, for the combustion produced in the Mahler bomb is to some extent explosive and immediate combustion should proceed throughout the entire mass in a manner precisely similar to the combustion of gunpowder. If the coal is pulverized to a powder it is liable to be thrown out of the disk into the bomb and escape combustion. The grains should, however, not be coarse, otherwise the combustion may be more or less incomplete. It is very important that a complete combustion be secured.

This granular coal, which should contain very little powdered coal, is sampled and placed in a small bottle from which all of the material for analysis is to be taken. The first determination is made upon 1 gram, weighed into a platinum crucible, holding about 30 cc. with a tightly fitted lid.

All of the samples tested for this paper were dried in an electric oven at a temperature of 180° F. The amount of water determined under these conditions can be duplicated any number of times on the same specimen to almost identity. The loss of weight gives the percentage of water directly.

The covered crucible was then placed in the flame of a Bunsen lamp and heated to bright redness for seven minutes, cooled and weighed. The loss of weight gives the percentage direct of volatile matter. This percentage is sometimes termed volatile combustible matter, but it is not necessarily all combustible matter in samples of hard anthracite.

The action of these samples indicates very conclusively that a part of this loss consists of occluded gases of varying composition. The sample in the open crucible was then burned to ashes and the ashes weighed. The combustion of white ash coals is quite rapid, but red ash coals and coals containing pyrite require a longer time for complete combustion. The ash is weighed and its weight noted. The percentage of ash and the difference in weight between the ash

and coal deprived of its volatile matter is computed as fixed carbon. These determinations divide the coal into moisture, volatile matter, fixed carbon, and ash. They may be almost indefinitely repeated to within a few thousandths of 1 per cent.

The determination is easy, rapid and exact, consequently while giving only proximate results, it is a very satisfactory method of analysis and I think it can be shown to constitute an indication of the quality of the coal that is both certain and exact.

If it is desired that a determination of the British Thermal units shall be had in addition to these results, resort is had to the Mahler bomb or some of its later modifications. Experience has shown that the Mahler bomb gives results under certain conditions that corroborate and emphasize the results obtained by combustion.

The results furnished by the Mahler bomb, however, cannot be exactly duplicated, in consequence of the fact that the operation of the instrument is more delicate than our observations, that is to say, we cannot read the thermometers to a degree of exactness corresponding to the variation in the efficiency of the instrument; for this reason, under the most favorable conditions, results will vary by a certain percentage. The action of the instrument is also more efficient at a given temperature, which if exceeded in consequence of very hot weather, or diminished in consequence of a low temperature, has a very marked influence in modifying the results obtained. Another cause of variation is observed to depend upon the amount of moisture contained in the specimen of coal. If the coal is at all wet or even damp, it is possible that the water may be decomposed by the carbon, the oxygen dissociated from the hydrogen, and the hydrogen burned as free hydrogen, thus increasing the apparent thermal units and destroying the values by a considerable percentage. I have repeatedly experienced an excess of thermal units, which I could explain in no other way. Another cause of error lies in carelessness in reference to the amount of coal taken for the assay. If much more than 350 milligrams is taken, the combustion is liable to be incomplete. The amount of assay was found on experience to be proportional to the volume of oxygen and any excess over 400 milligrams is liable to produce an incomplete combustion, particularly where there is a residuum of slate or bone.

The use of the Mahler bomb is thus shown to be subject to variation, while theoretically indicating the exact value of the coal for

heating purposes. Variation in the conditions under which the determination is made subjects the results to variation which can only be controlled with great difficulty and may result in proving the coal to be more efficient than it really is, or less efficient than it really is, the results being by no means as exact and constant as an ordinary laboratory determination, as for example those obtained by the proximate analysis which has before been described.

This subject has been agitated for several years by the City Government of New York. Formerly each department of the city purchased its own coal on such terms as it saw fit. The result was often found to be entirely satisfactory to the commissioners of one department, but were very unsatisfactory to those of another. One source of difficulty was found to lie in the varying and often antiquated, and sometimes wornout, plants in which the coal was burned. The varying results obtained, when estimated in dollars and cents, under these varying conditions, led to comparisons between the efficiency of city plants and those of privately owned plants, often greatly to the disadvantage of the city.

In consequence, a movement was made in the last months of 1909 to standardize the specifications under which coal was purchased for the city, with an idea that more satisfactory results would follow. In other words, that more heat could be obtained for a dollar expended.

A committee was appointed by Mayor McClellan which embraced in its membership representatives of all parties interested. The action of the committee, however, was delegated, by the chairman, to a sub-committee, in which practical experience was entirely overshadowed by academic and theoretical knowledge. It is not necessary to state the lack of fitness possessed by the chairman of this sub-committee, who was an accomplished physician, but no chemist. His influence over the committee, however, was very great.

A new administration took up this matter after January 1, 1910, but the influence of the theoretical advocates of paying money for heat actually obtained still held sway. The result was the adoption of specifications under which payments were to be made upon the contracts, based almost wholly upon the determination of British thermal units, developed by the combustion of the coal.

The result has been practically disastrous to the interests of the city.

Under the old specifications, the coal was required in most departments to contain, not to exceed 16 per cent of ash, nor less than 80 per cent of fixed carbon, a theoretical consideration that would demand a very fine quality of coal, but which can be easily shown to be wholly impracticable. Analyses of several hundred specimens of coal show no coal on the market that yielded 80 per cent of fixed carbon, contains 16 per cent of ash. Sixteen per cent plus 80 per cent is 96 per cent, leaving only 4 per cent to include water and volatile matter. The water will average, from our laboratory experiments, $2\frac{1}{2}$ per cent in air-dried coal. The volatile matter averages about 6 per cent. The volatile matter is a constant constituent of every variety and size of coal. The water may be removed by special care in drying, as I have analyzed samples that would not lose any water at a temperature of 212° F., but 99 per cent of all the coal that I have examined of all sizes, contained an average of $2\frac{1}{2}$ per cent of water when air dried. In consequence of these facts, it is impossible that the fixed carbon and ash remaining after the water and volatile matter had been removed should be equal to 96 per cent. The sum of the fixed carbon and the ash should never exceed $91\frac{1}{2}$ per cent, if a maximum of 16 per cent of ash is allowed. The minimum of fixed carbon would then not exceed 75 per cent, which would indicate a barely good sample of coal. It is impossible to pick from coal as small as buckwheat, all of the slate; it is also impossible practically, to prepare an average of a dozen samples of buckwheat coal obtained from any but the very finest mines that contains 80 per cent of fixed carbon. As a general rule, it is impossible to comply with these requirements as stated. The maximum, namely of 75 per cent, is too high for pea and buckwheat coal and 70 per cent would be more reasonable in the light of experience and could be more strictly enforced. The carbon contained in bone (which is only a very poor coal) and the mineral matter contained in the slate are included in the requirements for fixed carbon and ash and therefore take care of themselves. Bone, whether containing much or little carbon, is always included in the determination of the ash and fixed carbon made for the whole sample; if the bone is picked out and analyzed separately, it would leave the remainder of the coal richer in carbon and better than the whole sample.

The standardized specifications require that the coal delivered should conform to the following requirements.

Standard Analyses—Anthracite Coal. The quality of coal of

the different sizes contracted for shall conform to, or be superior to the coal described in the following standard analyses applying to such sizes:

Names of Sizes of Coal.	Maximum Allowable Moisture, Per Cent as Delivered.	Maximum Allowable Ash Per Cent Dry Coal.	Maximum Allowable Volatile Combustible Matter Per Cent Dry Coal.	Maximum Allowable Volatile Sulphur, Per Cent Dry Coal.	Minimum Allowable B.T.U.'s Per Pound Dry Coal.
Broken	4	11	8	1½	13,200
Egg	4	11	8	1½	13,200
Stove	4	12	8	1½	13,000
Nut	4	12	8	1½	13,000
Pea	5	16	8	1½	12,300
Buckwheat:					
No. 1	6	17	8	1½	12,200
No. 2	6	18	8	1½	12,100
No. 3	6	18	8	1½	12,000

These requirements are very high and their efficiency is entirely nullified by a provision for an aggregate deduction in gross tonnage as follows: "After the corrections for excess moisture shall have been made as herein specified, all percentage in deductions as above described to be made on account of a deficient number of British thermal units per pound, and an excess percentage of ash, volatile sulphur, and volatile combustible matter will be aggregated and totalized, and will be deducted as a whole, and payment will be made only for the balance of the gross tonnage at the price bid per gross ton furnished, delivered and stored and trimmed." That is to say, that after specifying the requirements of a very high grade of coal it is made possible to deliver any kind of coal that could be purchased.

I propose to demonstrate the truth of this statement by a series of tables which have been compiled from the results of the analyses of 100 samples of coal analyzed at the laboratory of the Department of Finance. These results are tabulated first, in extenso in Table I.

TABLE I

ANALYSES OF 100 SPECIMENS OF ANTHRACITE COAL

No.	Size.	Bone.	Slate.	Water.	Volatile Matter.	Fixed Carbon.	Ash.	B.T.U.
1	Broken	2.8	1.8	1.15	6.70	82.58	9.57	13.435
2	Broken	3.8	1.5	2.87	5.73	80.98	10.42	13.372
3	Broken	7.7	5.9	2.13	6.35	76.73	14.79	12.578
4	Broken	4.0	1.6	2.45	5.35	81.25	10.95	12.501
5	Egg	3.1	1.2	2.15	5.94	83.68	8.23	13.692
6	Egg	2.6	1.9	2.82	4.98	83.05	9.25	13.512
7	Egg	3.7	1.8	1.59	6.68	81.08	10.65	13.478
8	Egg	4.7	4.8	2.86	5.72	80.72	10.70	13.289
9	Egg	5.0	3.0	2.10	5.34	80.50	12.06	13.276
10	Egg	1.9	0.8	1.85	7.05	80.03	11.07	13.114
11	Egg	2.5	5.1	1.90	6.90	80.55	10.65	12.740
12	Egg	6.8	4.0	2.52	6.00	78.58	12.90	12.690
13	Egg	6.6	4.6	2.95	6.12	77.18	13.75	12.620
14	Egg	6.3	5.1	2.55	5.00	77.40	15.05	12.085
15	Egg	5.4	5.3	3.35	3.90	76.66	16.09	11.435
16	Stove	6.0	2.5	1.70	6.86	80.24	11.20	12.792
17	Nut	4.7	3.2	2.38	5.62	73.77	18.23	11.094
18	Pea	3.5	2.2	1.87	6.07	80.83	11.23	13.978
19	Pea	2.2	2.0	2.55	5.33	80.75	11.37	13.294
20	Pea	2.0	3.0	1.38	4.45	82.70	11.47	13.194
21	Pea	1.2	2.4	1.22	5.53	82.80	10.45	13.120
22	Pea	3.8	4.5	2.12	6.43	79.21	12.24	12.990
23	Pea	3.3	3.0	2.00	5.76	79.22	13.02	12.990
24	Pea	2.5	2.9	2.05	5.10	79.75	13.10	12.895
25	Pea	1.3	2.6	2.40	5.22	78.70	13.68	12.870
26	Pea	2.0	3.2	2.00	4.90	80.13	12.97	12.791
27	Pea	3.2	1.3	2.80	5.20	79.50	12.50	12.754
28	Pea	2.5	2.0	1.29	6.13	80.00	12.58	12.715
29	Pea	1.6	5.8	2.27	5.78	78.75	13.20	12.647
30	Pea	6.2	4.6	2.10	7.71	75.83	14.36	12.634
31	Pea	6.0	5.0	2.21	5.59	77.75	14.45	12.627
32	Pea	2.0	2.4	1.95	5.65	79.70	12.70	12.616
33	Pea	2.6	3.5	2.90	5.85	76.88	14.37	12.602
34	Pea	1.9	2.9	2.70	5.90	77.70	13.70	12.578
35	Pea	1.5	2.9	2.45	5.55	79.00	13.00	12.567
36	Pea	7.0	7.9	2.20	6.18	75.13	16.49	12.565
37	Pea	2.3	4.1	1.60	7.64	74.76	16.00	12.524
38	Pea	1.4	2.8	1.83	5.26	80.10	12.81	12.501
39	Pea	4.0	3.2	2.68	5.65	78.80	12.87	12.488
40	Pea	3.4	6.2	2.47	7.16	74.32	16.05	12.466
41	Pea	4.8	3.1	1.80	4.95	80.11	13.14	12.445
42	Pea	2.8	4.7	1.75	6.30	75.70	16.25	12.386
43	Pea	3.1	2.8	1.27	7.03	76.23	15.47	12.378
44	Pea	3.2	1.8	1.74	6.26	78.60	13.40	12.321
45	Pea	2.5	2.9	1.40	6.26	76.87	15.47	12.317

TABLE I—*Continued*

No.	Size.	Bone.	Slate.	Water.	Volatile Matter.	Fixed Carbon.	Ash.	B.T.U.
46	Pea.....	3.2	6.4	1.32	6.23	77.49	14.96	12.281
47	Pea.....	1.9	3.3	1.75	5.20	80.02	13.03	12.272
48	Pea.....	4.0	5.5	1.70	5.60	77.60	15.10	12.258
49	Pea.....	2.8	4.0	2.00	5.90	77.40	14.70	12.250
50	Pea.....	2.8	1.8	1.58	5.62	79.18	13.62	12.166
51	Pea.....	5.5	2.8	2.43	4.34	78.87	14.38	12.160
52	Pea.....	5.2	4.4	1.80	6.02	76.25	15.93	12.159
53	Pea.....	5.0	3.0	2.67	4.33	75.62	17.38	12.146
54	Pea.....	3.5	4.5	2.70	5.25	76.92	15.13	12.105
55	Pea.....	4.0	9.8	2.00	6.88	75.74	15.38	12.060
56	Pea.....	4.5	2.4	2.42	3.86	79.72	14.00	12.047
57	Pea.....	2.1	4.0	1.70	5.35	78.72	14.23	11.995
58	Pea.....	5.2	6.5	2.22	5.58	73.70	18.50	11.989
59	Pea.....	3.0	4.0	2.57	4.83	77.25	15.35	11.946
60	Pea.....	4.5	5.1	2.02	6.20	73.03	18.75	11.946
61	Pea.....	2.9	5.8	1.05	7.04	74.11	17.80	11.894
62	Pea.....	3.1	2.6	1.30	5.75	75.79	16.48	11.892
63	Pea.....	5.3	4.7	1.30	5.75	75.70	17.25	11.867
64	Pea.....	3.3	3.8	2.94	3.86	77.33	15.87	11.840
65	Pea.....	4.2	5.3	2.00	5.75	74.88	17.37	11.811
66	Pea.....	3.3	6.4	2.55	4.66	75.47	17.32	11.718
67	Pea.....	4.2	6.0	1.77	5.51	75.82	16.90	11.714
68	Pea.....	4.0	5.5	2.15	4.62	76.55	16.68	11.692
69	Pea.....	3.4	2.5	1.43	5.66	73.39	18.92	11.577
70	Pea.....	5.6	8.8	2.15	6.18	72.34	19.33	11.541
71	Pea.....	5.4	3.4	2.50	4.00	76.00	17.50	11.435
72	Pea.....	5.1	7.0	1.65	6.15	70.55	21.65	11.383
73	Pea.....	7.1	2.9	2.17	4.38	77.45	16.00	11.320
74	Pea.....	3.0	10.5	1.45	4.89	76.31	17.35	11.264
75	Pea.....	3.8	7.8	2.50	4.85	75.40	17.25	11.181
76	Pea.....	3.0	4.5	1.50	6.05	73.70	18.75	11.059
77	Pea.....	3.6	6.4	2.42	4.26	72.67	20.65	10.992
78	Pea.....	2.2	6.5	3.86	6.74	70.98	18.42	10.919
79	Pea.....	3.5	5.3	1.00	5.97	75.68	17.35	10.892
80	Pea.....	3.1	4.8	1.64	5.00	70.81	22.55	10.539
81	Pea.....	7.7	6.1	2.59	5.23	71.26	20.92	10.446
82	Buckwheat	1.6	4.0	1.32	6.33	76.25	16.10	12.427
83	Buckwheat	1.7	2.7	1.95	6.53	75.52	16.00	12.380
84	Buckwheat	1.8	4.1	1.90	5.57	78.93	13.60	12.180
85	Buckwheat	1.3	4.7	1.79	7.26	75.67	15.28	12.026
86	Buckwheat	2.0	6.0	2.51	5.94	75.87	15.68	11.916
87	Buckwheat	2.2	8.9	1.71	5.78	75.94	16.57	11.860
88	Buckwheat	3.4	2.7	3.50	5.94	74.44	16.12	11.838
89	Buckwheat	2.1	1.5	1.62	6.71	74.52	17.15	11.829
90	Buckwheat	2.0	4.5	1.45	6.22	75.15	17.18	11.666
91	Buckwheat	2.1	5.2	3.67	4.91	74.00	17.42	11.553
92	Buckwheat	3.0	4.5	2.78	3.44	77.70	16.08	11.495
93	Buckwheat	3.7	6.0	3.52	4.14	75.12	17.22	11.490

TABLE I—*Continued*

No.	Size.	Bone.	Slate.	Water.	Volatile Matter.	Fixed Carbon.	Ash.	B.T.U.
94	Buckwheat	2.1	5.0	3.00	4.10	75.52	17.38	11.382
95	Buckwheat	1.8	5.1	2.90	4.70	74.30	18.10	11.363
96	Buckwheat	1.5	3.5	2.40	4.10	78.42	15.08	11.356
97	Buckwheat	3.0	5.0	2.85	3.88	74.32	18.95	11.183
98	Buckwheat	2.9	3.7	2.23	6 42	68.92	22.43	11.064
99	Buckwheat	1.4	4.2	2.50	4.67	73.70	19.13	10.879
100	Buckwheat	2.5	6.0	3.35	4.78	69.37	22.50	10.202
101	Buckwheat	1.8	3.6	2.15	4.76	78.64	14.45	11.792

From these results as thus tabulated Table II has been computed:

TABLE II

Broken...	Yielding	B.T.U.	under	13,500	and above	13,000	were 2
Broken...	"	"		13,000	"	12,500	" 2
Egg.....	"	"		13,500	"	13,000	" 5
Egg.....	"	"		13,000	"	12,500	" 4
Egg.....	"	"		12,500	"	12,000	" 1
Egg.....	"	"		12,000	"	11,500	" 0
Egg.....	"	"		11,500	"	11,000	" 1
Stove....	"	"		13,000	"	12,500	" 1
Nut.....	"	"		11,500	"	11,000	" 1
Pea.....	"	"		14,000	"	13,500	" 1
Pea.....	"	"		13,500	"	13,000	" 3
Pea.....	"	"		13,000	"	12,500	" 17
Pea.....	"	"		12,500	"	12,000	" 18
Pea.....	"	"		12,000	"	11,500	" 14
Pea.....	"	"		11,500	"	11,000	" 6
Pea.....	"	"		11,000	"	10,500	" 5
Buck.....	"	"		12,500	"	12,000	" 4
Buck.....	"	"		12,000	"	11,500	" 6
Buck.....	"	"		11,500	"	11,000	" 7
Buck.....	"	"		11,000	"	10,500	" 2

Table III has been computed as follows:

TABLE III

	Yielded.		
	F.C. Per Cent.	Ash. Per Cent.	B.T.U.
9 samples very good egg.....	80.59	11.03	13.388
1 sample fair egg.....	77.40	15.05	12.085
1 sample very poor egg.....	76.66	16.09	11.435
1 sample stove coal.....	80.24	11.20	12.792
1 sample poor nut.....	73.27	18.23	11.094
4 samples very good pea.....	81.77	11.13	13.399
17 samples good pea.....	78.35	13.59	12.697

The average of 4 samples of broken coal gives F. C. 80.38 per cent, ash 11.43 per cent, B.T.U. 12.971.

The average of the whole 21 samples of very good and good pea was F. C. 80.03 per cent, ash 12.35 per cent, B.T.U. 13.046.

Eighteen samples of good pea yielded: F. C. 77.52 per cent, ash 14.96 per cent, B.T.U. 12.262.

The average composition of the 39 samples of good and very good pea yielded F. C. 78.77 per cent, ash 13.66 per cent, B.T.U. 12.604.

	Yielded.		
	F. C. Per Cent.	Ash. Per Cent.	B.T.U.
14 samples of poor pea	75.29	17.19	11.744
11 samples very poor pea	73.98	18.94	11.039
4 samples buck size, very good	76.59	15.25	12.253
13 samples buck size, good	73.37	17.33	11.548
2 samples buck size, poor	71.53	20.81	10.540

Of these 100 specimens 29 were delivered at the municipal ferry houses at St. George, Staten Island, and at 39th Street, South Brooklyn. The deliveries were made by one firm under the old specifications during about one-half of the year and the other half of the year they were made by new contractors under the new specifications which admit of corrections which nullify the force of the specified requirements. Under the old specifications, the contractors were held to the specified requirements by frequent tests made by different parties, and hence confirming each other.

In January four deliveries averaged F. C. 80.71 per cent, ash 12.32 per cent, B.T.U. 13.032.

In February six deliveries averaged F. C. 79.72 per cent, ash 12.85 per cent, B.T.U. 12.786.

In March, two deliveries averaged F. C. 76.28 per cent, ash 16.36 per cent, B.T.U. 12.092.

In April, two deliveries averaged F. C. 78.00 per cent, ash 14.05 per cent, B.T.U. 12.285.

In May, four deliveries averaged F. C. 79.36 per cent, ash 12.66 per cent, B.T.U. 12.788.

In June, three deliveries averaged F. C. 79.48 per cent, ash 12.61 per cent, B.T.U. 12.879.

Average for six months, F. C. 78.93 per cent, ash 13.47 per cent, B.T.U. 12.642.

In August the deliveries under the new specifications began with coal averaging F. C. 80.11 per cent, ash 13.14 per cent and B.T.U. 12.445 and ended with a delivery that averaged F. C. 75.68 per cent, ash 17.35 per cent and B.T.U. 10.892.

The delivery of poor coal at these ferries produced two very marked results. First, it nearly doubled the labor required of the firemen. Second, it nearly doubled the labor and expense of removing the ashes produced in such large quantities.

I am told that it was only with great effort on the part of the firemen, that steam could be maintained at the proper pressure to give the ferryboats the required speed.

A more graphic use of these averages can be made by averaging them.

For the first six months the average delivery gave F. C. 78.93 per cent, ash 13.47 per cent, B.T.U. 12.642. If these requirements were used in the specifications drawn from such a large number of samples there would be no necessity for deduction in accordance with fine spun theories without practical value, having for their object, on the part of the city officials, to get the heat that is paid for, and on the part of the contractors the practical avoidance of the required obligations and the deliveries of coal containing so much slate that thousands of tons of slate are being sold to the city.

Anyone who will take the trouble to examine these results of the analyses of 100 specimens can easily discover that a constant inverse ratio exists between the amount of ash obtained on analysis and the B.T.U. determined by the calorimeter. At the same time a direct ratio exists between the amount of fixed carbon by the analysis of anthracite coal and the B.T.U. as obtained by the calorimeter. For practical purposes the determination of the B.T.U. offers no additional information as to the value of the sample of anthracite.

The results obtained by the calorimeter simply confirm the results obtained by the determination of the fixed carbon and ash, adding nothing to these results. In the table of 100 specimens there are a total of 64 samples of pea coal, among these 64 samples every grade of pea coal on the market, from the best to one so poor that it will

scarcely answer for steam purposes, may be found. They were delivered all over Greater New York and the testimony of the engineers, as to the efficiency of these samples was repeatedly confirmed by the results of the analysis.

The difference between good and poor coal does not correspond in efficiency to the direct difference obtained by deductions and corrections under these new specifications. The difference between a coal which is nearly worthless and which really will not pay for carting about the city, yielding on combustion in the calorimeter between 10,000 and 11,000 B.T.U.'s, and a coal containing so little impurity, that it will yield in the calorimeter from 13,000 to 14,000 B.T.U.'s, does not represent, in efficiency, the difference between 10/14 and 14/14, but represents more nearly 75 per cent of the total efficiency obtained on the combustion of the pure coal.

So far as I know, no attempt has been made to determine exactly what these deductions should be, but they are in practical use proved to be more nearly represented by geometrical than arithmetical ratio; hence the disastrous effects witnessed in the practical use of the poor for good coal and proved by the practical experience on the municipal ferries.

A still further striking illustration of the lack of practical value in the determination of B.T.U. is offered by the specimen numbered in the Table 101. My assistant one day was called in haste to the American Museum of Natural History. He came back with a sample that was called coal, which represented a delivery to the Museum. When sifted for sizes, this sample yielded the following:

	Per Cent.
Retained on $\frac{1}{4}$-in. mesh sieve (No. 1 buckwheat).....	27.8
Retained on $\frac{1}{8}$.-in. mesh sieve.....	58.9
Retained on 1/16.-in. mesh sieve.....	4
Passed 1/16 -in. mesh sieve.....	9.3

The material smaller than No. 2 buckwheat was 66.6 per cent the whole and this consisted largely of pulverized coal; while it yielded to the calorimeter 11.792 of B.T.U. and it contained only 14.45 per cent of ash and yielded 78.64 per cent of fixed carbon, it was still so finely divided that it would not burn and steam could not be maintained with it. These figures representing the approximate analysis of the coal, indicate a good coal. The material was really the sweepings of a coal shed or a barge and was not No. 2

buckwheat coal at all. Yet someone, who claimed to represent the firm who delivered the coal, came to my office and declared that inasmuch as the coal yielded 11.792 B.T.U.'s, the city had got to accept it and use it. In this case neither the proximate analysis nor the calorimeter, nor both combined, ensured that the city got what it paid for.

TWO METHODS OF TESTING ASPHALT

By S. F. PECKHAM

Read at the Chicago Meeting, June 23, 1911

At the last meeting of the Institute of Chemical Engineers, at the Hotel Astor in New York, last December, John Purroy Mitchell, who welcomed the members of the Institute to the city, announced, according to the *Times*, that the city had decided to establish and maintain a fully equipped chemical laboratory for the examination of all chemicals purchased by the city. He said that this laboratory would be governed by a Board of Directors, who would be men of high standing in their profession. Manufacturing chemists have been urging the city for some time to establish such a laboratory. They say the present laboratories of the city are not equipped to do the work satisfactorily, and that as a result the city often pays dearly for poor material. With such a laboratory as has been suggested, manufacturers and chemical engineers say that such a thing as graft or favoritism in the granting of contracts will be impossible.

Of course, I need not say to the members of this Institute that this wished for result will depend entirely upon the Board of Directors and the men selected by them to conduct said laboratory. As an illustration in point, I will relate the following facts:

A short time prior to the meeting of the Institute in December, one of the engineers attached to the Department of Finance of the city brought to me four samples of asphaltic material, two of which he said he wished me to compare with the other two. Accompanying these samples was the manuscript of an unsigned report, which had been made upon them, which is as follows:

Analysis of the sample of rock asphalt mined at Asphalt, Edmonson County, Ky., shows that it is asphaltic sandstone, and has the following composition:

LABORATORY TEST NO. K–6687

		Per Cent
Bitumen		8.2
	Passing 200-mesh sieve	5.5
	Passing 100-mesh sieve	2.3
	Passing 80-mesh sieve	1.0
	Passing 50-mesh sieve	24.0
Sand,	Passing 40-mesh sieve	22.0
	Passing 30-mesh sieve	29.5
	Passing 20-mesh sieve	5.5
	Passing of 10-mesh sieve	2.0

Analysis of the sample of Asphalt Mastic manufactured from the above, and known as "Standard Kentucky," resulted as follows:

LABORATORY TEST NO. K–6688

		Per Cent
Bitumen		12.3
	Passing 200-mesh sieve	28.9
	Passing 100-mesh sieve	8.2
	Passing 80-mesh sieve	2.1
Mineral,	Passing 50-mesh sieve	22.5
Aggregate,	Passing 40-mesh sieve	7.5
	Passing 30-mesh sieve	9.8
	Passing 20-mesh sieve	3.1
	Passing 10-mesh sieve	3.0
	Retained on 10-mesh	2.6

A 10-lb. weight resting on an area of four square inches of this mastic at a temperature of 90° F., for 1 hour, caused no appreciable indentation.

Analysis of the sample of Ragusa Rock Asphalt showed that it is an asphaltic limestone of the following composition:

LABORATORY TEST NO. K–6689

	Per Cent
Bitumen	8.2
Limestone	90.6
Sand	1.2

Analysis of the sample of Asphalt Mastic manufactured from the above rock asphalt has the following composition:

LABORATORY TEST NO. K–6690

		Per Cent
Bitumen		16.8
Mineral, Aggregate,	Passing 200-mesh sieve	30.2
	Passing 100-mesh sieve	12.0
	Passing 80-mesh sieve	2.6
	Passing 50-mesh sieve	12.0
	Passing 40-mesh sieve	2.5
	Passing 30-mesh sieve	2.5
	Passing 20-mesh sieve	4.0
	Passing 10-mesh sieve	7.4

A 10-lb. weight resting on an area of four square inches of this mastic at a temperature of 90° F. showed no appreciable indentation.

Respectfully,

——— ———, CHEMIST.

The engineers, as usual, were in a great hurry, apparently thinking that such examinations could be made in a few hours.

The four samples were labeled as follows:

713A was a sample of Kentucky Rock which I have had in my possession for several years, and was one of a number of samples of such rock that I have examined at intervals.

713B was a sample of Mastic reputed to have been made from Kentucky Rock.

714A was a sample of Ragusa Sicilian Rock Asphalt.

714B was a sample of Mastic reputed to have been made from the Sicilian Rock of which 714A was a sample.

I have examined at different times a number of samples of Kentucky rock reputed to have been taken from this locality, in the area, that is, in which such rock is found. These analyses all showed that the Kentucky rock consists of a very sharp-grained hard sandstone, that was a solid rock before it was saturated with bituminous material. The percentage of bitumen in the different samples varied, as might be expected to result from the varying degree of porosity of the rock. The sandstone, in all cases, however, was a very compact rock after the bitumen was removed.

The problem submitted was to determine the identity or resemblance between 713B and 714B. It was not expected that, inasmuch as the natural Kentucky rock is a sharp-gritted sandstone and the Ragusa rock is a soft chalk, consisting almost entirely of carbonate of lime and magnesia, that any identity could be established between the original Kentucky rock and Ragusa rock from which the mastics were made.

The two mastics, however, were to be, according to the specification, identical or equal to each other. The four samples were subjected to chemical experiments and a physical test.

Chemical Experiments

Portions of the four samples were broken into coarse fragments, care being taken not to pulverize the samples, and weighed in duplicate portions of 5 grams each. These portions did not contain pieces larger than a pea. They were placed in stoppered funnels with balanced filters. The samples were made as nearly alike as possible under the circumstances and they were all treated with petroleum ether out of the same bottle of a specific gravity of 90° Baumé, until the ether passed colorless.

The solutions in petroleum ether were variously colored. 713A, by transmitted light, was *dark red;* by reflected light, *dark brown.*

713B was, by transmitted light, *light red;* by reflected light, a strong *green fluorescence.*

714A was, by reflected light, *brown*; by transmitted light, *red.* 714B was the same.

These different colors indicate that the three numbers, 713A, 714A, and 714B, did contain a different bitumen from 713B. 713B must have consisted in large proportions of some sort of petroleum residuum which may or may not have been mixed with other natural bitumens, the proportion of petroleum residuum being sufficient to disguise the other ingredients.

I have examined hundreds of natural bitumens and have never found a specimen of asphaltum or bituminous rock from any part of the world to yield a solution in petroleum ether having a green fluorescence. Solid asphaltum and the bitumen of asphaltic rocks invariably yield a brown solution in petroleum ether.

The exhausted filters were dried and weighed against the balanced filter and then returned to the funnels, where they were

exhausted with boiling spirits of turpentine. The residues from the boiling turpentine were treated with 95 per cent alcohol and after being thoroughly exhausted of the turpentine were dried and weighed. The dried filters were then returned to the funnels and exhausted with chloroform.

These different solutions and residues yielded the following percentages:

	713A.	713B.	714A.	714B.
Petroleum ether	5.603	8.204	7.189	10.622
Boiling turpentine	1.765	4.389	1.860	6.101
Chloroform	0.387	1.272	zero	zero

From an inspection of this table it will be observed that the two samples 714A and 714B were exhausted of bitumen by treatment with petroleum ether and spirits of turpentine.

These results indicate two very different varieties of bitumen. The bitumen of the limestone asphalts of Europe is wholly soluble in spirits of turpentine and in this respect is quite different from almost any other variety of bitumen. There was no indication of a mixture of any petroleum residuum in either 714A or 714B.

The following table gives the percentage of the total bitumen found in the four different specimens which yield to a solution of the three solvents:

	713A.	713B.	714A.	714B.
Petroleum ether	72.25	59.20	78.75	63.5
Boiling turpentine	22.75	31.65	21.25	36.5
Chloroform	5.00	9.15	zero	zero

The total bitumen found in the four samples is as follows:

713A.	713B.	714A.	714B.
7.755	13.865	9.049	16.723

The total composition of the four specimens is:

713A.—Bitumen, 7.755, sand, 92.245.
713B.—Bitumen, 13.865, sand, 45.675, carbonate of lime, 40.460.
714A.—Bitumen, 9.049, carbonate of lime, 90.951.
714B.—Bitumen, 16.723, carbonate of lime and sand, 83.277.

This specimen of 713A consisted, like all other samples of Kentucky rock, of bitumen saturating a sandstone hard and sharp-gritted. 713B consisted of bitumen 13.865 per cent, sand 45.675 per cent, pulverized limestone 40.460. These ingredients indicate a material that is practically a street mixture prepared from sand, powdered limestone and bitumen, the bitumen consisting largely or wholly of petroleum residuum.

714A consisted of bitumen 9.049, carbonate of lime 90.951. The carbonate of lime contained, as is usual with chalk formations, a small percentage of grit, which in the unbroken rocks are usually found to be siliceous shells. 714B consists of bitumen 16.723, the remainder consisting practically of carbonate lime, but containing a larger proportion of silica than the limestone residuum from 714A.

The excess of silica may have been added, or, as it is more likely, it may have been a constituent of the natural rock from which the mastic was prepared.

These results show, as far as chemical results can show, that 713A was natural Kentucky rock; 713B was a mixture identical with or resembling a street mixture, consisting, as before stated, of sand, pulverized linestone and bitumen that was wholly or largely petroleum residuum. 714A is natural Ragusa bituminous limestone. 714B was a mastic prepared from such limestone with an addition of bitumen that was probably extracted from poor rock out of the same quarry.

Physical Tests

Portions of 713B and 714B were pulverized in the first instance completely and in the second instance only partially, as it was very difficult to reduce the Ragusa mastic into small fragments. These crushed portions were compacted into a mold such as is used in making cement briquettes. One was prepared at laboratory temperature, a second was prepared by warming the mass to a temperature of about 180° F. They were allowed to cool and set over night and were broken the next morning in the cement testing machine, with the following results:

713B cold, broke at 170 lbs.
713B hot, broke at 210 lbs.
714B cold, broke at 176 lbs.
714B hot, broke at 189 lbs.

Both briquettes 713B broke short, while both 714B stretched before breaking in such a manner as to render the exact determination of the point at which they broke difficult. The briquettes made from Ragusa rock were very much more elastic than those made from so-called Kentucky rock. The halves of the broken briquettes were very nearly of the same size. They were exactly alike in shape and were an inch thick, with a superficial area approximating two square inches.

These broken briquettes were crushed in an Olsen machine and were found to sustain the following crushing pressures:

713B cold sustained a crushing pressure of 3600 lbs.
713B hot sustained a crushing pressure of 3000 lbs.
714B cold sustained a crushing pressure of 4200 lbs.
714B hot sustained a crushing pressure of 5200 lbs.

All of these varied experiments, both chemical and physical, established the fact beyond any question that the mastics were neither identical nor equivalent and that the mastic prepared from Ragusa rock is very greatly superior to the so-called Kentucky rock mastic.

The inadequacy of any proof of identity or equality between these specimens exhibited by the unsigned report needs no further demonstration than a perusal of the reports of these two materials. The mastic was to be used in one of the city parks for walks, over which, at certain seasons of the year, a constant stream of pedestrians was moving. The fact that a 10-lb. weight on a surface of 4 sq.ins. made no impression is ridiculously inadequate. The mastic walks were to be continually used at a temperature often reaching 120° F. in the sun, and subject to the impressions of boot heels, supporting a weight of 10, 15 or 20 times 10 lbs. If the conditions under which this report was made were not as serious as they really are, the report might be denominated a complete farce.

EXPLOSIVES USED IN ENGINEERING AND MINING OPERATIONS

By CLARENCE HALL, Explosives Engineer, U. S. Bureau of Mines

Read at the Washington Meeting, Dec. 20, 1911, by permission of the Director of the U. S. Bureau of Mines

General Statement

The application of explosives to engineering and mining operations has increased rapidly in recent years. According to the preliminary report issued by the Census Bureau 469,000,000 lbs. of explosives were manufactured in this country during the year 1909, and the greater part of this production was used for industrial purposes. The economic importance of explosives is recognized since their use has rendered possible the removal of masses of rock, building of roads and railways, winning of ores and coal, removal of obstructions to navigation, such as at Hell Gate, New York, and for many other purposes which, by other means, would have been either impossible, or carried out at an enormous expenditure of time and money.

In large engineering projects and in mining operations where the work is directly dependent upon the use of explosives, the selection of a suitable explosive from the many varieties offered for sale in this country is of fundamental importance. Many considerations are involved in the selection of the proper class of explosives used in connection with mining and engineering operations. Explosives suitable for quarry work are generally unsuited for deep mines or in close workings. In wet-workings or in submarine blasting, cartridges of explosives impervious to moisture are requisite. In extremely cold climates, explosives which do not require thawing are desirable, other conditions being equal. In metalliferous mining and in driving tunnels the character of the gases evolved on the deto-

nation of explosives is one of the important considerations. Explosives for use in gaseous or dusty coal mines must be formulated so as to have the flame temperature and the height and duration of the flame moderated to such an extent that they can be used with comparative safety. The salient feature in connection with all explosives, and especially those for use in tropical countries, is that they shall remain stable and not alter or change in their chemical or physical character.

Explosives Used in Quarry Operations

Practically every class and grade of explosive is used in open work to meet the varying conditions. In breaking down rock in quarries the following explosives are generally employed: Black blasting powder, granulated powder containing 5 to 15 per cent nitroglycerin, straight nitroglycerin dynamites varying in grade from 15 to 60 per cent nitroglycerin, low-freezing dynamites rated according to the equivalent percentage of strength of the straight nitroglycerin dynamites, and ammonia dynamites rated in a similar way. In recent years blasting gelatin, gelatin dynamites, ammonium nitrate powders containing nitro substitution compounds, chlorate powders, and the so-called nitrostarch powders have been introduced to a limited extent in quarry operations.

Black Blasting Powder

Black blasting powder is a mechanical mixture consisting of finely pulverized sodium nitrate, intimately associated with combustible materials. In order to cause this intimate association of the materials they are thoroughly mixed and incorporated in what are technically termed wheel mills. The product is pressed into hard cakes which are subsequently granulated in the form of small grains. The edges of the grains are rounded by rubbing together in a revolving barrel, and at the same time the surfaces are coated or glazed, as it is termed, by graphite or black lead. The object in rounding and glazing the grains is to render them free running, and the glazing also serves to delay somewhat the taking up of moisture from the air. The following is the composition of black powder such as is generally offered for sale in this country.

Charcoal	16	per cent
Sulphur	11	"
Sodium nitrate	73	"
	100	"

The powder is divided into grades according to size, as separated and collected by sieves of different sizes of openings. The sizes most usually offered for sale are called CC, C, F, FF, FFF, and FFFF. Of these CC represents the largest grains about $\frac{1}{2}$ in. in diameter, and FFFF represents the smallest grains about $\frac{1}{16}$ in. in diameter.

Gases and Pressure Produced

When blasting powder is ignited in a drill hole a rapid combustion takes place, and the force exerted by the highly heated gases which are formed produces the useful effects.

It has been found that 150 liters (5.30 cu.ft.) of gas are produced from 454 grams (1 lb.) of black blasting powder, measured at normal temperature and pressure, viz., 0° C., 760 mm. When the number of liters of permanent gas produced by black blasting powder is compared with the volume of permanent gases produced by the detonation of equal weights of nitroglycerin dynamites, it is evident that there are other factors of more importance than the amount of permanent gases evolved when considering the energy developed by explosives.

At the instant of explosion the gases are highly heated and expanded, and tend to occupy a much greater volume than when measured at normal temperatures and pressures. The theoretical temperature produced at the instant of explosion of dynamite is much higher than that which obtains on the explosion of black blasting powder and, accordingly, the gases evolved on the detonation of dynamite are more highly heated and expanded.

Time Element

The factor of time must be taken into account in considering the energy developed by explosives. It is this phenomenon: namely, rate of detonation or burning that determines the characteristic features of commercial explosives, and it is the governing factor in

judging the efficiency as well as offering the best means for selecting suitable explosives to meet the varying mining conditions. During the conversion of an explosive into solid, liquid, and gaseous products the cooling produced by the walls of the drill hole, or other heat-absorbing surroundings, tends to reduce the temperature of the gases so that the theoretical temperature or the maximum pressure is never reached. The more nearly instantaneous the explosion reaction for a given explosive, all other conditions being equal, the greater the volume of highly heated gases will be produced, and the more violent the effect.

The rate of burning of FF black blasting powder as determined at the Pittsburgh testing station under conditions simulating those which obtain when powder is exploded in a drill hole has been found to be 469 meters (1538 ft.) per second. This rate is relatively slow when compared with the rate which obtains on a detonation of ordinary dynamites. For this reason the gases from the combustion of black blasting powder are formed at a comparatively slow rate and with a corresponding loss of heat and pressure due to conduction and radiation. Under these conditions, the pressures produced are prolonged and black blasting powder is, therefore, best suited for work where a gradual pushing or heaving effect is desired. In order to obtain the maximum efficiency with black blasting powder the charge must be well confined by suitable stemming. The most successful results are obtained when the drill holes are tamped to the mouth.

Black blasting powder is used in excavating cuts, quarrying soft rock or stone, and especially in quarries where large building stone is sought. In some work it is necessary to chamber the bottom of the drill hole with dynamite or other suitable high explosives before charging with black blasting powder. When this procedure is followed a large cavity is formed at a point where the powder can be placed to the best advantage. When drill holes are chambered in this way they become hot and should not be reloaded immediately after firing a shot, for under these conditions the charge may explode prematurely.

Granulated Nitroglycerin Powders

The following composition is an example of granulated powder such as is generally offered for sale in this country:

Nitroglycerin	5.0	per cent
Combustible material *	35.0	"
Sodium nitrate	60.0	"
	100.0	"

* Consists of sulphur, coal, and resin.

The composition of the grains of granulated nitroglycerin powders is somewhat similar to black blasting powder. Instead of thoroughly incorporating and mixing the nitrate and combustible materials, these ingredients are heated at a temperature which melts the resin and sulphur. The sticky mass which is formed is then granulated by cooling, and at the same time rubbing it through a fine mesh screen.

The grains produced in this way are hard and porous and can be superficially coated with a small percentage of nitroglycerin. To procure the maximum efficiency when using a granulated powder it is necessary to detonate the charge with a priming cartridge of dynamite. The nitroglycerin which is superficially held in the interstices and on the outside of the grains is detonated and accelerated combustion of the powder grains is brought about. The rate of detonation of granulated powder has been found to be 1018 meters (3339 ft.) per second and, accordingly, is more than twice that which obtains on the burning of black blasting powder. It is due to this fact that granulated powder has been found to be more effective and to give better results than black blasting powder when used in soft and seamy rock.

Straight Nitroglycerin Dynamites

The following compositions are examples of the straight nitroglycerin dynamites, such as are generally offered for sale in this country.

	%	%	%	%	%	%	%	%	%	%
Nitroglycerin	15	20	25	30	35	40	45	50	55	60
Combustible material *	20	19	18	17	16	15	14	14	15	16
Sodium nitrate	64	60	56	52	48	44	40	35	29	23
Calcium or magnesium carbonates	1	1	1	1	1	1	1	1	1	1
	100	100	100	100	100	100	100	100	100	100

* Consisting of wood pulp, flour and sulphur for grades below 40 per-cent; other grades wood pulp only.

The rate of detonation of 30 per cent and 60 per cent straight

nitroglycerin dynamites has been found to be 4548 meters (14,920 ft.) per second and 6246 meters (20,490 ft.) per second respectively.

The straight nitroglycerin dynamites as a class have also been found to develop more dynamic energy than any of the other commercial types of explosives, and for this reason should be used whenever the conditions permit for producing shattering effects or in blasting very tough or hard materials.

If straight nitroglycerin dynamites are found to be too violent for certain classes or work, the low-freezing dynamites or the ammonia dynamites which have lower rates of detonation and give a more heaving and rending action may be used to advantage.

Low-freezing Dynamites

The following table shows typical compositions of low-freezing dynamites:

Ingredients.	30% Strength.	35% Strength.	40% Strength.	45% Strength.	50% Strength.	55% Strength.	60% Strength.
Nitroglycerin.	23	26	30	34	38	41	45
Nitro substitution compounds.	7	9	10	11	12	14	15
Combustible materials *.	17	16	15	14	14	15	16
Sodium nitrate.	52	48	44	40	35	29	23
Calcium or magnesium carbonate	1	1	1	1	1	1	1
	100	100	100	100	100	100	100

* Composition similar to the straight nitroglycerin dynamites.

The low-freezing dynamites have the advantage of not freezing until a temperature of 35° F. or less is reached, but like all nitroglycerin explosives, when they become frozen, it is necessary to thaw them before using in order to procure the most effective results.

Ammonia Dynamites

The ammonia dynamites, however, have the disadvantage, compared with the other dynamites, of taking up moisture readily, and care should be taken in storing or using them in wet places. The following table shows typical compositions of ammonia dynamites:

Ingredients.	30% Strength.	35% Strength.	40% Strength.	50% Strength.	60% Strength.
Nitroglycerin	15	20	22	27	35
Ammonium nitrate	15	15	20	25	30
Sodium nitrate	51	48	42	36	24
Combustible material*	18	16	15	11	10
Calcium carbonate or zinc oxide	1	1	1	1	1
	100	100	100	100	100

* Composition similar to the grades below 40 per cent straight nitroglycerin dynamites.

Gelatin Dynamites

For use in wet blasting in removing obstacles to navigation, and in deep workings, the gelatin dynamites have been used to a large extent and as a general rule are best adapted for these purposes. In the process of manufacturing gelatin dynamites, the nitroglycerin is first gelatinized by adding a small percentage of nitrocellulose. In this way a jelly-like mass is formed which is impervious to water, and by adding different percentages of suitable absorbents the various grades of gelatin dynamites are made.

The following compositions are examples of gelatin dynamites generally offered for sale in this country:

Ingredients.	30% Strength.	35% Strength.	40% Strength.	50% Strength.	55% Strength.	60% Strength.	70% Strength.
Nitroglycerin	23.0	28.0	33.0	42.0	46.0	50.0	60.0
Nitrocellulose	0.7	0.9	1.0	1.5	1.7	1.9	2.4
Sodium nitrate	62.3	58.1	52.0	45.5	42.3	38.1	29.6
Combustible materials *	13.0	12.0	13.0	10.0	9.0	9.0	7.0
Calcium carbonate	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Wood pulp used in 60 and 70 per cent strengths. Flour, wood pulp and sometimes resin and sulphur used in other grades.

Some manufacturers replace a small percentage of the nitroglycerin in these grades with an equal amount of ammonium nitrate, however, it offers little, if any, advantage other than reducing the cost of manufacturing.

Explosives used in Mining and Tunneling Operations

It is generally recognized that in driving tunnels, sinking shafts, and in metalliferous mining where the removal of hard rock is necessary, explosives having a high percussive force are preferable. In work of this kind the cost of drilling holes is of great importance and it has been found more economical to drill a few holes and load with an explosive having a high percussive force rather than to drill a larger number of holes and use weaker and cheaper explosives. It is also equally important that explosives used in this class of work should produce the minimum amount of poisonous gases.

From what has been said in the foregoing pages in reference to the composition and the characteristics of the different classes of explosives it is evident that black blasting powder, granulated nitroglycerin powder, low-freezing dynamites, and the ammonia dynamites would not be suitable or satisfactory for use in work of this kind for they do not develop the requisite percussive force; furthermore, these explosives in common with the straight nitroglycerin dynamites produce poisonous gases which vitiate the atmosphere of the working places.

Products of Combustion

The Bichel pressure gauges, which are used for determining the theoretical maximum pressures developed by explosives, are also used for collecting the gaseous, liquid and solid products of combustion. The same method is used in preparing and firing the charge as is followed in determining the maximum pressures developed, except that the indicator mechanism is replaced by a pressure gauge. After the charge is fired the gases are allowed to cool for 30 minutes, the pressure is recorded and the volume of gases at 760 mm. and 0° C. is computed. A differential sample of the gases is then taken over mercury by allowing the gases to escape gradually from the gauge. A charge of 200 grams of the explosive in original wrapper was used in all tests, except with black blasting powder which was fired in charges of 300 grams.

The results of tests showed that the low-freezing dynamites produced on detonation the maximum amount of poisonous gases. In one sample the gaseous products of combustion contained 47.47 per cent by volume of carbon monoxide. The straight nitroglycerin

dynamites produced quantities of carbon monoxide varying from 26.9 to 34.6 per cent, black blasting powder produced 10.8 per cent carbon monoxide and 8.7 per cent hydrogen sulphide, granulated powder produced 2.7 per cent carbon monoxide and 15.7 per cent hydrogen sulphide, and ammonia dynamite produced 3.8 per cent monoxide and 5.4 per cent hydrogen sulphide. The gelatin dynamites were found to give the least amount of poisonous gases on detonation, namely, 3.0 per cent carbon monoxide and 4.1 per cent hydrogen sulphide, but even this class of explosives is far from being satisfactory in this respect. Nevertheless, the gelatin dynamites are used to a large extent in this country in metalliferous mining and tunneling operations.

The ventilation in the workings is usually defective and the work requires the use of large quantities of explosives. Many accidents have occurred as a result of the vitiation of the air in deep workings from the poisonous gases evolved on the detonation of explosives. In one of the large Western engineering projects, nine men recently lost their lives as a result of the poisonous gases produced on the detonation of 40 per cent strength gelatin dynamite.

It was soon after this accident that studies of the noxious gases evolved on the detonation of explosives were undertaken by the explosives section of the Bureau of Mines to find out if improvements could be made in the composition of explosives with a view to thus increasing safety in mining operations.

Formula for a Mine Explosive

From what has been said before it is evident that there are only two classes of explosives available which develop the percussive force required for this class of work; namely, straight nitroglycerin dynamite and gelatin dynamite. To construct well balanced formulas for the straight nitroglycerin dynamites it would be necessary to reduce the percentage of combustible materials in order that an oxygen deficiency would not obtain. This could be accomplished by replacing the wood pulp in the higher grades with some inert material having a high absorbing capacity like magnesium carbonate or kieselguhr, but as this method would materially decrease the efficiency of the explosive by reducing the quantity of active matter, it was thought advisable to conduct certain experiments with gelatin dynamites which do not require combustible material for absorbing the nitroglycerin.

Several samples of 40 per cent strength gelatin dynamite were procured from different manufacturers, and it was found that all samples produced poisonous gases on detonation, the percentage of carbon monoxide varying from 3 to 5.7 per cent.

On inspection of the formulas for gelatin dynamites given on page 310, it will be noted that there is apparently sufficient oxygen in the sodium nitrate to completely oxidize the combustible materials, and for this reason all the formulas are said to be well balanced. However, the gauge tests showed that quantities of hydrogen sulphide were evolved on detonation and remained in the permanent gases. It was concluded that the sulphur used in the gelatin dynamites was responsible for this condition and should be eliminated as an ingredient. The result of further investigations showed that the heavy coated paraffined paper wrappers used in connection with the explosive and which represented a comparatively large percentage by weight of combustible material had not been given due consideration by the manufacturers of explosives. It was believed that by slightly increasing the percentage of sodium nitrate, sufficient oxygen would be provided to completely oxidize the hydrogen and carbon contents of the paper wrapper.

As a result of the investigations a quantity of 40 per cent strength gelatin dynamite was manufactured according to the following formula:

Nitroglycerin	33 per cent
Nitrocellulose	1 "
Sodium nitrate	54 "
Combustible material *	11 "
Calcium carbonate	1 "
	100

The results of tests showed that this modified formula for 40 per cent strength gelatin dynamite on detonation in metal gauges did not evolve poisonous gases, but the question was raised that this condition might not obtain when large quantities were detonated under actual mining conditions. It was then decided to supplement

* Flour. The products of combustion were determined in the gauge, using 200 grams of the explosive in the original wrapper under the same conditions as in previous tests.

the gauge tests by tests in the field. The first experiments were carried out in a limestone mine at West Winfield, Pa. As this limestone was mined by the room and pillar method the procedure followed was to shoot "off the solid" face four or more shots, depending on the width of the face of the workings. This necessitated the use of different amounts of explosives in the different working places. No. 6 electric detonators were used and the shots connected in series and fired at one time.

The second series of experiments were carried out in a zinc mine at Franklin Furnace, N. J. The headings in which the tests were made average about 5 ft. in width and 7 ft. in height. In driving these headings a 21 hole cut was used. The first shot which is fired in the center of the face is known as a "burning" shot. The object is not to blast out any material, but to form a crack in the center of the face or to disintegrate the rock so that when the first round of shots is fired the material can be blasted out. The method of loading and firing the second, third and fourth rounds of shots is similar to that generally followed in metal mining operations. In taking some of the mine air samples it was necessary to use a breathing apparatus. The samples were taken by air displacement by means of a small bellows which was emptied and filled fifty times.

The results of the field tests, although limited in extent, with a few exceptions, confirmed the tests made in the pressure gauge.* The odor of hydrogen sulphide was noticeable immediately after firing some of the explosives containing sulphur as an ingredient, but the chemical analyses of the mine air samples failed to disclose the presence of any appreciable amount of this gas. There were several days intervening between the taking of the samples in the mine and the chemical examinations and it may be possible that if there were minute quantities of hydrogen sulphide present in any of the samples, the hydrogen sulphide was altered or otherwise changed, by reason of standing so long. It is worthy of note that in all tests made the explosives were completely detonated and the formation of nitrogen oxides did not obtain.

The results of experiments indicate that all gelatin dynamites should be made with a sufficient oxygen excess to completely oxidize all combustible materials, including the paraffined paper wrappers; furthermore, the tests show that when this type of explosive is

* The results of laboratory and field tests are now being prepared in tabulated form and will be published as a technical paper by the Bureau of Mines.

properly and completely detonated the amount of harmful gases evolved is reduced to a minimum. However, it should be remembered that these conditions will not obtain if there has been any chemical or physical change in the explosive or if it is fired under conditions which would cause an incomplete detonation or burning. Under these conditions a greater quantity of poisonous gases will be evolved. These conditions will obtain when the explosive has aged to such an extent as to materially decrease its sensitiveness, when weak donators are used, or if the explosive is used in a frozen or partially frozen condition.

Determination of the Relative Energy and Efficiency of Explosives

It is evident in hard-rock blasting operations, where a shattering effect is desired, the explosive reaction should be rapid, and explosives should be selected having a high rate of detonation. In the same manner, a suitable explosive for use in soft and friable ground should be selected which develops gases at a slow rate, in order that the pressure developed will be more prolonged. In medium hard rock it would be expected that the explosive having an intermediate rate would be most suitable, but this procedure cannot always be followed. The lack of uniformity in the character of rocks and the fact that a perfectly homogeneous mass or bed rarely obtains is a factor that has to be considered in blasting operations. In the Middle West there are fairly uniform deposits of limestone 12 to 14 ft. thick in which quarry operations are being conducted. In one of these quarries which the writer visited, stone was being produced in one part of the quarry at a cost of 6 cents per ton for explosives used. In this part of the quarry an explosive having a low rate of detonation gave satisfactory results. In another part of the same quarry a different type of explosive having a much higher rate of detonation was found necessary in order to produce the stone at the same cost. This was due to the local irregularities such as clay slips and bedding planes which were more pronounced in this part of the quarry. It had been found by practical experience that an explosive which developed its gases at a slow rate expended much of its energy by gases escaping through the clay slips and thus reduced its efficiency.

After a suitable type of explosive has been selected it is necessary

to determine the grade or strength of the explosive which will be best adapted and which will produce most economical results. It is well known that the potential energy of an explosive can be computed by measuring the heat evolved on explosion in a calorimeter. The potential energy thus obtained represents the maximum work that an explosive can theoretically accomplish. But as the useful work which obtains from explosives is a very small percentage of the theoretical maximum, and, furthermore, as it varies considerably with the different types of explosives, knowledge of the potential energy is of little value to the engineer in selecting a suitable explosive. As an example, it may be stated that blasting gelatin which is considered the most powerful blasting agent known, and, hence, the ideal explosive, on account of its high potential energy, has seldom given satisfactory or economical results in practical operations in this country. This is probably due to the fact that the physical character of blasting gelatin does not permit of a high rate of detonation with the means or devices ordinarily used in this country for causing the detonation of explosives.

Apparatus for Testing Explosives *

It has been impossible to devise a single apparatus for measuring dynamic and static effects produced by explosives. The apparatus used at the Pittsburgh testing station for determining these factors which concern the relative strength of explosives will be briefly described, together with a tabulation of the results of tests made with different explosives.

Measurements of Potential Energy. The apparatus which measures the potential energy of explosives is the calorimeter. (See Fig. 1.)

Calorimeter

The explosives calorimetor is constructed on the principles usually followed in calorimeters by which the chemical reaction is carried on between the reacting bodies while they are enveloped by a mass of water of known weight and whose increase in temperature may be observed and measured with a high degree of precision. The calorimeter bomb is air-tight and previous to the experiment, while the

* For a more detailed description of the apparatus see Chapter IV. Bulletin 15. "Investigations of Explosives Used in Coal Mines," U. S. Bureau of Mines.

charge is within it, practically all of the air is pumped out by means of a rotary pump. It is not necessary for any oxidizing material to be used in the calorimeter other than that supplied by the explosive itself. The charge used is 100 grams. The bomb is large and strong in order that the pressures resulting from the explosion may be safely held. The bomb has a capacity of 30 liters and weighs

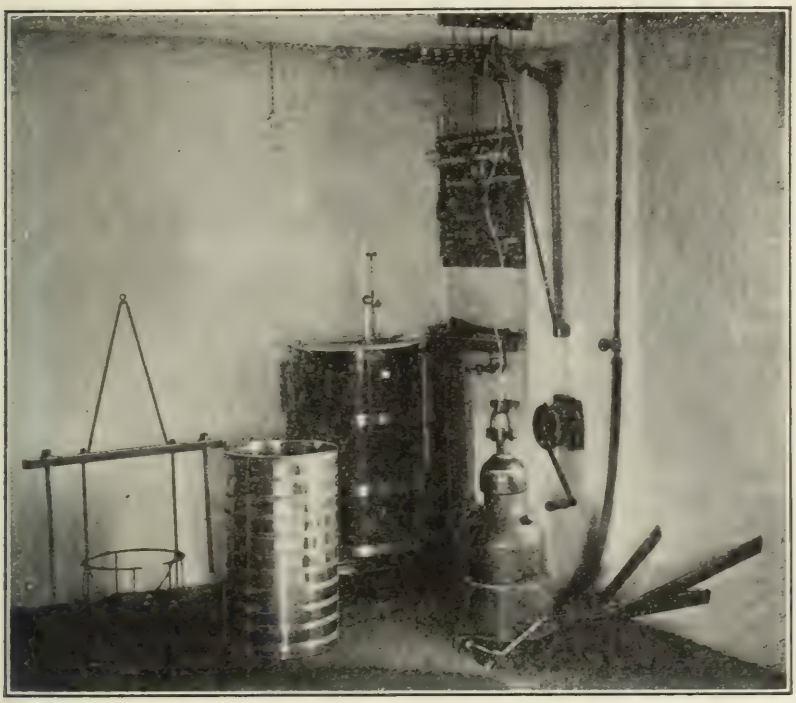


FIG. 1.—Calorimeter.

158 lbs. It is provided with a cover through which the charge may be placed in the bomb, a valve through which the air may be pumped, and an insulated plug which is used to carry the electric current to the detonater which is placed in the charge. The water completely surrounds the bomb and the inner receiver is of such size that the quantity of water used is 182 lbs. The rise in temperature is measured by a centigrade thermometer reading to thousandths of a degree.

Measurements of Dynamic Action. The apparatus which measures largely the dynamic action, and which corresponds closely to the percussive or shattering force of explosives, are the rate of detonation, Trauzl blocks, and small lead blocks.

Rate of Detonation

The rate of detonation apparatus consists of Mettegang's recorder

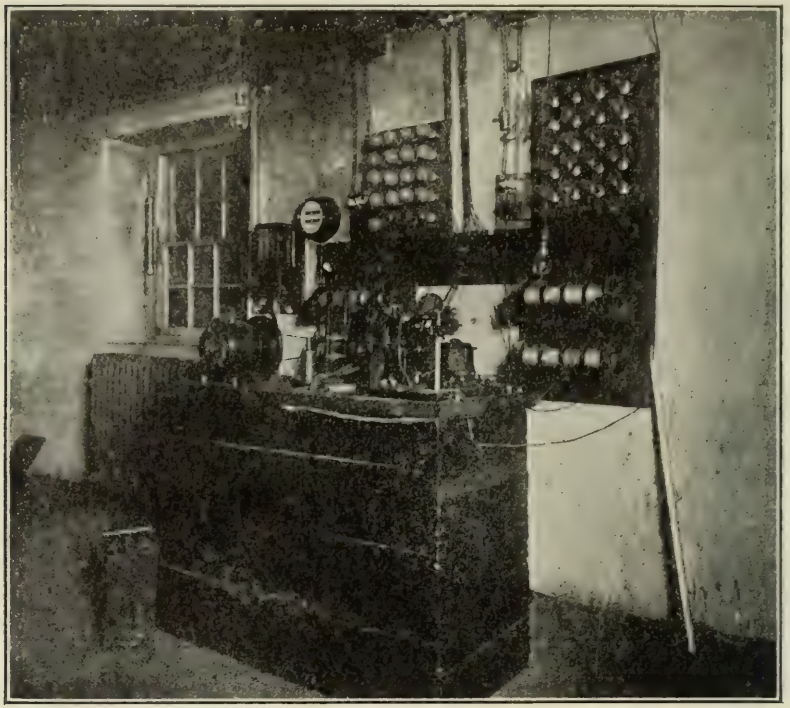


Fig. 2.—Mettegang's Recorder.

and a covered pit in which the charge is placed previous to the test. (See Fig. 2.)

Mettegang's recorder consists of a soot-covered bronze drum, pointed platinum terminals, tooth gear and measuring adjustment, electric motor, vibration tachometer, and induction coils the primaries of which have no iron cores. The drum is 500 millimeters

in circumference and may be driven at any speed up to 105 revolutions per second. One edge of the drum is provided with teeth of which there is the same number as there are millimeters in the circumference. An endless screw engages these teeth and a pointer on this screw moves on a dial. Four platinum terminals are held by a non-conducting arm which may be so moved that the points are any desired distance from the drum. Each point is in series with a secondary coil, the other terminal of which is grounded to the drum through the base of the machine. Each primary coil is in series with ten 16-candle power lamps and a copper wire running through one end of the cartridge file. The current used in the primary circuit has a potential of 220 volts. The vibration tachometer is connected to an auxiliary shaft which engages the main shaft by gears, thus preventing any irregularity in speed due to slipping. The points of the drum are fixed on the cross hairs of a filar eyepiece which, with the endless screw, provides an exact method for measuring the distance between the two points. The pit in which the cartridge file is suspended is 16 ft. in diameter and 11 ft. deep, and is closed at the top by means of a heavy reinforced concrete cover. The manhole in this cover provides an entrance to the interior. The determination was made on a cartridge file of explosive $1\frac{1}{4}$ ins. in diameter and 1 meter in length, enclosed in a galvanized sheet iron tube 42 ins. long and $1\frac{1}{2}$ ins. internal diameter. Copper wires leading from Mettegang's recorder are passed through the cartridge file 1 meter apart, and from the time between the breaking of these two wires, as determined by the recorder, is computed the rate of detonation.

The rate of burning of black blasting powder was determined by placing it in a hydraulic pipe having an inside diameter of $1\frac{1}{2}$ ins. One end of the pipe was filled with 4 ins. of plaster of Paris and the other end with 1 in. of plaster of Paris. The charge was fired by means of an electric igniter. The time interval was determined by means of Mettegang's recorder in the usual way.

A unique method for determining the rate of detonation of explosives, known as the Dautriche method,* is as follows:

A cartridge or explosive file is suspended freely in the air, and at two points on the cartridge at known distances apart are placed two

* For extended discussion of this method see "Study of the Velocity of Detonation," by Mr. Arthur N. Comey, page 28, 7th International Congress of Applied Chemistry, Section III*B*, Explosives.

detonators into each of which is previously crimped one end of a continuous length, usually one meter, of detonating fuse. This fuse is bent so as to lie on a lead plate $\frac{1}{2} \times 3 \times 15$ ins. in such a way that the center of the detonating fuse is directly over a previously marked position on the lead plate. As the detonation proceeds through the cartridge of explosive it initiates a detonation by means of the detonators, first, from one end of the detonating fuse and later in the other end of the detonating fuse. The detonation proceeds from both ends of the detonating fuse and the position on the lead plate where these detonations meet is easily determined. The detonating fuse has a known rate of detonation and from this, together with the distance between the mark on the lead plate corresponding to the center of the detonating fuse to the position on the lead plate where the detonations meet, may easily be computed the time of detonation of the cartridge of explosive. This detonating fuse is known as Cordeau detonat, is made in diameters of 4 and 6 millimeters, costing about 10 to 15 cents per yard, and may be procured in this country from the Ensign-Bickford Company, Simsbury, Conn. A few tests have been made at the testing station of the Bureau of Mines with this Cordeau detonat. The results obtained are fairly uniform and compare favorably with the results obtained with Metegang's recorder as heretofore described.

Trauzl Lead Blocks

The Trauzl lead block test was conducted in the manner approved by the Fifth International Congress of Applied Chemistry. No effort was made to confine the explosive by means of plates and yoke. A charge of 10 grams of explosive was used, tamped with dry sand to the mouth of the borehole, and fired in an axial borehole 25 millimeters in diameter and 125 millimeters in depth, in a cylindrical block of desilverized lead 200 millimeters in diameter and 200 millimeters in height. The expansion of the borehole is determined in cubic centimeters by measuring the volume of the bore-hole with water before and after firing.

Small Lead Blocks

The small lead blocks are cylindrical in shape, $2\frac{1}{2}$ ins. long and $1\frac{1}{2}$ ins. in diameter. Each block is enclosed in a piece of paper in such a way that a shell is formed above the block in which to place the

charge. An annealed steel disk, $1\frac{1}{2}$ ins. in diameter and $\frac{1}{4}$ in. high, is placed on the top of the block. The block is placed on a firm horizontal base previous to firing the charge. The charge used weighs 100 grams, its specific gravity is normal. The electric detonator is placed centrally in the top of the charge. Compression of the lead block is determined in millimeters from its height before and after the explosion of the charge. This test is not adapted for testing black blasting powder, as it offers little confinement to the charge.

Measurement of Static Action. The apparatus which measures largely the static action and which corresponds closely to the heaving or pushing force exerted by explosives, are the pressure gauges and ballistic pendulum.

Pressure Gauges

The pressure exerted by explosives is determined by means of Bichel pressure gauges. (See Fig. 3.) The test determines the theoretical maximum pressure developed by an explosive in its own volume after the elimination of the cooling influence of the surface of the gauge. The apparatus consists of an air pump and proper connections for exhausting the air in the gauge to absolute pressure of 10 millimeters of mercury. Two stout steel cylinders which may be made air-tight, are each equipped with an insulated plug for providing a means of igniting the charge, a valve by means of which this air pump can be isolated from the cylinder, and an indicator mechanism, the drum of which may be driven by a motor at known speed. One of the cylinders has a volume of 15 liters. The cover of the cylinder is a heavy piece of steel held in place by 12 heavy stud bolts and an iron yoke. The piston of the indicator has a diameter of 0.3937 of a centimeter and is resisted by one of several different strength spiral springs. The particular one used is determined by the character of the explosive tested. The graphic record of the pressure developed within the cylinder is recorded on an indicator paper which is placed on the circumference of the drum. The other pressure gauge is similar to the 15 liter gauge in all particulars except that its volume is 20 liters. However, one or three steel cylinders can be placed in it to reduce its volume. The 15 liter gauge has a cooling surface of 3914 square centimeters. The 20 liter gauge has a cooling surface with one large steel cylinder of 6555 square centimeters,

and with the three smaller steel cylinders of 7624 square centimeters. The charge of explosive used is 200 grams plus the paper wrapper. This paper wrapper bears the same relation to the weight of the explosive used in the test as it does in the original cartridge. Each result is the computed pressure in own volume as determined by the following formula:

$M = \frac{VPS}{W}$ in which V is volume of the gauge which is always 15,000 cubic centimeters; S— specific gravity of cartridge, and W—

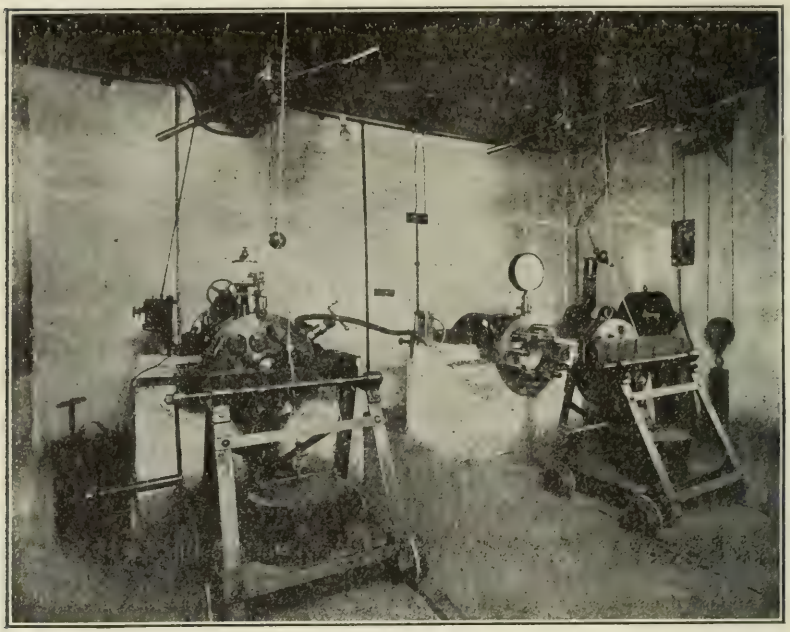


FIG. 3.—Bichel Pressure Gauge.

weight of charge used in the test. P is determined by means of the following formula, which is the algebraic expression of the geometrical solution determined by plotting the pressure resulting from averaging two tests within 5 per cent for each cooling surface against the cooling surface extending the line through these three points to the ordinate of zero cooling surface. In this way the effect of the cooling surface is eliminated: $P = 1.911a + 0.5b - 1.411c$.

Ballistic Pendulum

The ballistic pendulum is used to measure the deflective force of explosives. (See Fig. 4.) The apparatus consists of a 12.2 inch mortar suspended as a pendulum from a beam having knife edges, separated by two massive concrete piers, a cannon mounted on

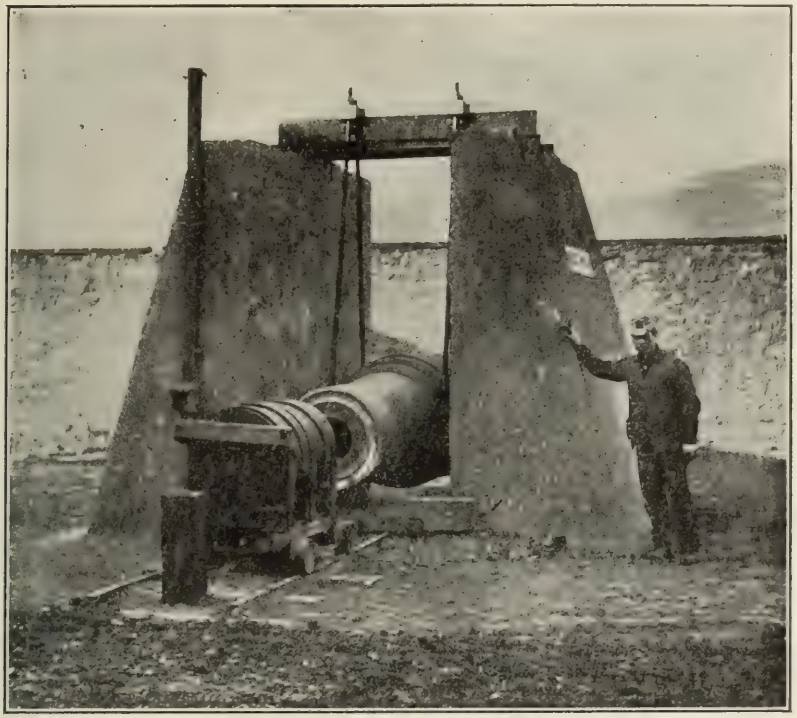


Fig. 4.—Ballistic Pendulum.

a truck, a track upon which the truck rests, and an automatic recording device. The mortar weighs 31,600 lbs. and hangs in two " U "-shaped rods. The rods pass through and are held by two cast steel saddles which fit over the supported beam. The radius of the swing measured from the point of the knife edges to the center of the trunnions is $89\frac{3}{4}$ ins.

The swing of the mortar is measured by an automatic recording device which consists of a movable scale and a vernier set on a metal

base fastened to a concrete footing. The scale is actuated by a long rod set in guides which bears against a stud bolt in the bottom of the mortar directly below its center of gravity. The scale moves tangentially to the swing of the mortar; the radius of the wing measured from the knife edge bearings to the center of the rod or base of the stud is 114 7/16 ins. The swing is measured to the one-hundredth part of an inch. The standard unit of comparison is a charge of 227 grams (½ lb.) of straight 40 per cent nitroglycerin dynamite.

The explosive to be tested is charged in the cannon without air space around the charge. One pound of dry fire clay is used as a stemming in front of the charge. The charge is fired with a No. 6 electric detonator. In testing the method of procedure is as follows: Two trials are made with 227 grams of straight 40 per cent nitroglycerin dynamite and the average of the two swings taken as the unit swing. One or, if necessary, more preliminary trials are then made with the explosives being tested to determine the approximate unit deflective charge. Two trials are then made with this weight of explosive and if the average swing of these two trials is within 3/16 of an inch of the standard swing, the unit deflective charge is computed from this preliminary charge by direct proportion as follows: The average swing for the explosive is to the unit swing as the trial charge is to the unit deflective charge. The distance of the cannon from the muzzle of the mortar is always 1/16 of an inch, a small distance being necessary to accommodate the legs of the electric detonator or electric igniter. In order that the mortar may always hang from the same center the knife edges are trammeled before every trial.

Pendulum Friction Device

A new test for determining the sensitiveness of explosives to frictional impact has been adopted by the Pittsburgh testing station. The apparatus consists of a smooth steel anvil 3¼ ins. wide by 12 ins. long, in the middle of which is placed three grooves for holding the charge of explosive. A smooth, swinging steel shoe having a radius of curvature of 10.5 ins. and radius of swing of 6 ft. 6¾ ins. is used in connection with the anvil. The shoe may be dropped from heights of ½ meter to 2 meters, and weights 1 to 20 kilograms are used in the tests.

The test was devised to represent conditions which obtain in

practice when a cartridge of explosive becomes lodged in a drill hole and it is necessary to exert force in order to ram the cartridge home. It has been found that some explosives are extremely sensitive to frictional impact even when wood fiber is used, consequently great care should be exercised with all explosives in charging drill holes.

As a result of a series of tests made the following tabulation has been prepared showing the comparison of the potential, dynamic, and static energy of the various classes of explosives.

The percentage strength representing potential energy is the calorimeter result; the percentage strength representing dynamic energy is the average of the rate of detonation, Trauzl lead block, and small lead block percentages; and the percentage strength representing static energy is the average of the pressure gauge and ballistic pendulum percentages. In each case the 40 per cent straight nitroglycerin dynamite is taken as the unit of comparison with a value of 100 per cent.

Comparison of Potential, Dynamic and Static Energy of Explosives

Brand.	Per cent Strength Representing Potential Energy.	Average Percentage Strength Representing Dynamic Energy.	Average Percentage Strength Representing Static Energy.
30% straight nitroglycerin dynamite.	93.1	84.1	96.8
40% straight nitroglycerin dynamite.	100.0	100.0	100.0
50% straight nitroglycerin dynamite.	111.0	109.2	107.4
60% straigth nitroglycerin dynamite.	104.0	119.8	114.9
60% strength low-freezing dynamite.	60.2	93.5	91.2
40% strength ammonia dynamite....	101.8	67.9	99.1
40% strength gelatin dynamite.....	105.7	78.4	95.8
5% granulated powder.....	67.6	21.6	53.3
Black blasting powder.....	71.6	6.8	58.6

Practical Value of Physical Tests

The figures given in this table are fairly consistent with general practice and it is believed this classification will serve as a useful guide for comparing the practical value of explosives. It is worthy of note that the potential energy of 40 per cent ammonia dynamite

and 40 per cent gelatin dynamite (that is to say, the theoretical maximum work which these explosives can accomplish) is higher than 40 per cent straight nitrogylcerin dynamite, but that the dynamic and static energy, which represents the useful work that obtains, as shown by actual tests, is less than that of 40 per cent dynamite. Accordingly, 40 per cent straight nitroglycerin dynamite will be more economical for use in blasting operations if the conditions and the character of the work are such as will permit of its use; nevertheless, the 40 per cent ammonia dynamite and 40 per cent gelatin dynamite will be found to be more efficient and economical for certain kinds of work that require explosives having high static and comparatively low dynamic energy. As an example, in blasting very soft rock, 40 per cent dynamite which has a very high percussive force may be too quick in action, while the ammonia dynamite or gelatin dynamite, having practically the same heaving and pushing action and less percussive force, will be more suitable. The tests also show that 60 per cent strength low-freezing dynamite is not quite equivalent to the 40 per cent straight nitroglycerin dynamite.*

Explosives Suitable for Coal Mining Operations

Permissible Explosives

Explosives suitable for use in gaseous or dusty coal mines are of an entirely different class from those previously mentioned in this paper. In addition to possessing the requisite qualities of strength and efficiency in breaking down coal, it is necessary that they be formulated so as to give on explosion a relatively short and cool flame. To bring about this condition free water and an excess of carbon are added to some of the coal mining explosives while others contain flame-reducing salts. To determine if an explosive is satisfactory in this respect requires careful testing. To carry out such tests the Bureau of Mines has installed at the Pittsburgh testing station suitable equipment, including a large testing gallery that can be filled with fire damp or coal dust with air in any desired proportion. As the equipment for testing coal mining explosives has been frequently described in the various technical journals, I presume the members present are familiar with the apparatus used. Explosives

* The 60 per cent low-freezing dynamite contained by analysis 2.61 per cent moisture and 41.43 per cent nitroglycerin. This may be cited as one of the many reasons for the need of the standardization of explosives in this country.

which pass certain tests and when used in accordance with the conditions prescribed by the Bureau of Mines are called permissible explosives and are recommended for use in coal mines.

The underlying reasons why one explosive passes and another fails when tested in the presence of gas and dust have been investigated at the Pittsburgh testing station. The results of the researches made, especially on explosives which failed to pass tests, have been reported to the manufacturers and in nearly all cases have resulted in the manufacturers so changing and perfecting their explosives that later when new explosives were submitted they have successfully passed all requirements of the bureau. The results of tests indicate that any explosive if fired in very large quantities will cause ignition of gas and coal dust mixtures. An arbitrary charge, namely, 1½ lbs., has been established as the amount of explosive to be used in making tests and all explosives in order to be placed on the permissible list must pass the gas and dust test with this charge of explosive. A charge of 1½ lbs. per drill hole should never be exceeded in practice. In good mining practice it need not exceed 1 lb., and, accordingly, a greater factor of safety will obtain. It has been found that in order to ignite inflammable gas and coal dust mixtures a certain temperature, acting through a certain length of time, is required. It has also been determined that the temperature of all explosives on detonation exceeds the ignition temperature of inflammable gas and dust mixtures, but fortunately the flame of a permissible explosive when properly detonated is of such short duration that the requisite time necessary for igniting the inflammable mixtures does not obtain. It is evident that any factor that increases the duration of the flame temperature of a permissible explosive, such as the use of an improper detonator or the use of any explosive not in accordance with the provisions prescribed by the Bureau of Mines, will increase the danger in their use.

Permissible explosives are now being used in every coal mining state in the Union. In 1909 there were 9,592,000 lbs. of permissible explosives used in this country. In 1910 the amount used reached 11,900,000 lbs., and it is believed that the year of 1911 will also show a further marked increase in the use of permissible explosives.

It is gratifying to note that there has been a declining tendency in the death rate in coal mines where permissible explosives are used and it is expected that there will be a steady reduction of accidents in the coal mines of this country in the future.

Discussion

The President:

I wish to add my thanks for those of the Institute to Mr. Hall for presenting such a valuable paper to us, and I can only wish that the views of Mr. Hall may coincide with ours in expressing the hope that we may at some time count him among the members of the Institute.

Dr. Reese:

I would like to ask Mr. Hall whether, in the tests made in the mines, any tests were made for nitric oxide?

Mr. Hall:

In all field tests made the explosives were completely detonated, and for this reason no nitric oxides were evolved, at least no appreciable amount could be detected by a careful chemical analysis in any of the samples taken.

Dr. McKenna:

Is a special kind of fuse needed for the rate of detonation test?

Mr. Hall:

The fuse is manufactured abroad but it can be purchased in this country.

Dr. Reese:

It is a fuse manufactured with trinitrotoluol or picric acid by pouring the melted explosive into a lead tube and then drawing this down to a small diameter of say $\frac{3}{16}$ in. according to the patent of Lheur. The test is an extremely interesting one but requires some practice to make it accurately. The velocity of detonation of this fuse has been found to be quite constant, practically 5000 meters per second, and the velocity of an explosive can be determined within an accuracy of about 5 per cent. The results with it have been checked with those obtained by the use of Bichel's chronometer and require very much smaller quantities of explosive than the latter, consequently can be carried out without creating as much disturbance in the neighborhood.

Dr. McKenna:

I understand Mr. Hall to say that it could be done by hanging a stick in the air. Is that different from Comey's method?

Mr. Hall:

We suspend it in the air above the lead plate so that the plate is not disturbed when the shot is fired.

A Member:

Mr. Hall, do you mean that the fuse is suspended above the plate?

Mr. Hall:

No, the cartridge of explosive is suspended. We are so congested at Pittsburgh that we have to conduct the tests inside of a large gallery.

Dr. Reese:

I would like to ask Mr. Hall whether he has made any experiments with such powders as are called " Fumicides."

Mr. Hall:

We have had compositions sent to us and it was claimed that they would neutralize the fumes and poisonous gases evolved on the detonation of explosives. The results of tests made indicate that the compositions offered no advantage in preventing or neutralizing the poisonous gases evolved on the detonation of explosives.

A Member:

I notice in listening to the description by Mr. Hall that in testing powders in the laboratory there is an explosion in the absence of atmosphere, while when testing in the mine there is an explosion in the presence of the atmosphere. You must not lose sight of the fact that this universal reagent is present in actual practice and while carbon monoxide and other gases might be present in the absence of oxygen, it is quite probable that a large part of them are consumed when these hot gases meet the atmosphere, and if I draw the right conclusions from the analysis of the mine air gases, such gases as CO and H_2S and possibly CN have disappeared in actual practice. It is very necessary that all of our tests should take into consideration all the factors of the equation, and when you are going to use something in the presence of the atmosphere, or exploded in the atmosphere, a test which explodes it in the absence of the atmosphere is not regarded by the practical man as being a good test.

Mr. HALL:

When tests are made with explosives in the gauge the air is purposely removed for the reason that we try to simulate the conditions of firing charges of explosives in drill holes. The air is practically excluded from a drill hole when it is filled with a charge of explosive and stemming.

PROBLEMS IN THE MANUFACTURE OF C. P. ACIDS

By J. T. BAKER

Read at the Washington Meeting, Dec. 20, 1911

THE manufacture of chemically pure acids, hydrochloric, nitric and sulphuric, is a subject concerning which very little if any literature is to be found. The reason for this is mainly that the manufacture of acids which will pass to-day as chemically pure is limited to comparatively recent years and the methods of manufacture have not yet found their way into chemical publications and text books.

Twenty-five or thirty years ago the yearly production of C. P. acids probably did not exceed one month's production at the present time, and owing to the enlarged field of analytical chemistry, the demand is constantly increasing. The manufacture has now reached a volume which entitles it to be classed as one of the large industries of the country and there are several manufacturing plants devoted in part if not altogether to this particular branch of chemical industry.

As a result of the growth of the business, manufacturers have been stimulated, if not obliged by reason of competition, to devise improved methods of manufacture, in consequence of which the cost of production has been materially reduced and the market prices have fallen during the period mentioned from 50 to 75 per cent. In this connection it is interesting to note some of the improvements which have been made, and the ingenuity which has been displayed in overcoming some of the almost insurmountable difficulties.

The improvements referred to and to be herein described relate only to the methods of purifying so-called commercial grade or crude acids and not to the actual manufacture of the acid itself, the latter being made by the usual methods more or less familiar to every student of industrial chemistry.

There is doubtless plenty of literature on the chemistry of making pure acids, but the chemistry is generally the simplest part of the problems of industrial chemistry, particularly when working on a

large scale, for the greatest problems encountered are generally the mechanical details and cost of production. When working on a large scale where the output is in tons instead of pounds, the conditions are totally different and laboratory methods will not apply.

It is only within the last score of years that the industry has advanced beyond the laboratory scale both in its methods as well as in the volume of its output. For many years the distillation of the crude acid was performed in glass retorts or flasks of 2 or 3 gallons capacity connected with small Liebig condensers in practically the same manner that distillations are performed in a college laboratory, only on a larger scale, and the amount of labor involved together with the loss from breakage made the cost of production not only high but uncertain. It was an interesting sight to see a battery of say 20 or 30 retorts side by side on a long sand-bath, each one having a separate condenser with numerous water-pipes and stop-cocks, all boiling at once; but when one retort accidentally cracked followed probably by half of the whole battery and the contents suddenly disappeared in a dense cloud through the ventilators of the roof, the sight was rather disheartening.

The great problem was to devise a still of small capacity but with a large heating surface which could be operated continuously by supplying crude acid as rapidly as the distillation proceeded, so that the quantity of acid in the still at any one time should never be very great and consequently little lost in case of breakage. Another advantage to be gained by such an arrangement would be the saving in time in getting the distillation started, as there would be but a small volume of liquid to be heated, while in a large still much time is lost in bringing the contents up to the boiling-point, not to mention the loss of heat by radiation from the sides of a large vessel.

One great difficulty, however, connected with such still, is the necessity of removing the impurities remaining in the tailings, which if allowed to become concentrated beyond a certain point will cause trouble by crystallizing out or spurting and being carried over into the distillate, while if an arrangement is made to draw off the tailings either continuously or intermittently, when using a still of the ordinary compact form, such as a retort or flask, much good acid is liable to be wasted.

An ideal still that will solve the problem is illustrated in Fig. 1,

and consists of a long glass tube with an opening at one end to admit fresh acid and one at the other end to draw off the tailings, the openings being in the form of traps to prevent the escape of the vapors, for which an exit is provided near the end at which the acid is admitted.

The still is kept about half-full and is heated from underneath along the entire length, the greatest heat being at the end near the exit of the tailings. The still being long and narrow there will be a constant movement of the contents toward the outlet, at which point the impurities will collect and will gradually be drawn off with the tailings at a rate that will avoid any trouble from crystallizing or spurting. Even if spurting should occur at this point, it is so far from the exit for the vapors that there is no danger of any of the impurities being carried over into the distillate. With a constant

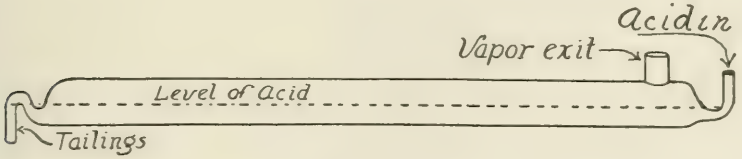


FIG. 1.

supply of fresh acid entering the still to replace the contents as rapidly as it distills off, the distillation may be kept up indefinitely.

Such a still as the above, while perhaps practicable as a laboratory experiment, would not answer for operating on a large scale, because owing to the fragile nature of the material available for the purpose, it is not possible to construct such an apparatus that will be durable. The same principle involved has, however, been worked out successfully in various other ways and some of the apparatuses designed are protected by patents.

One of the original inventions known as the Hart System and one which has proved to be as efficient as it was ingenious, is constructed of glass test tubes. The apparatus is illustrated in Fig. 2. A porcelain vessel in the form of a pipe say 4 ft. long, 6 ins. diameter, is made with a row of openings close together along one side, into which glass tubes closed at one end similar to a test-tube, say 18 ins. long by $1\frac{1}{2}$ ins. diameter, are inserted and the joints made tight with rubber gaskets or asbestos fiber. The vessel is provided with

a small opening at each end, one for the supply of fresh acid and the other for drawing off the tailings, and a larger opening on top to carry off the vapors. The vessel is supported on the brick-work of the furnace with the glass tubes depending downward and exposed to the direct heat of the fire.

A number of such apparatuses may be connected together and are placed on a level so that when the acid is admitted it will by seeking its level be at the same depth in each vessel and on a level with the outlet for the overflow of the tailings. The boiling takes place in the glass tubes, which afford a large heating surface, and the distillation is exceedingly rapid but may be easily controlled by regulating the temperature of the fire. The durability of the tubes depends upon the quality of the glass, but as a rule they stand

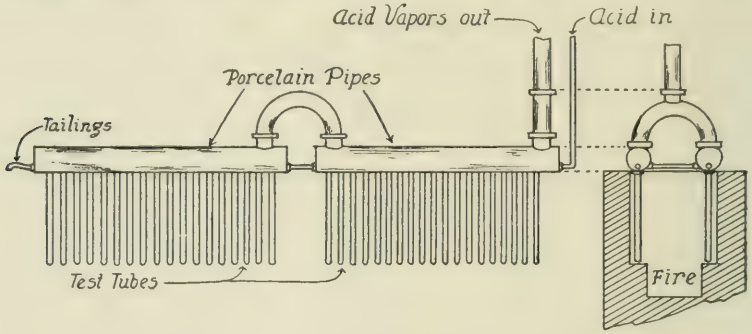


FIG. 2.

the strain well and with proper care on the part of the operator, the apparatus works quite satisfactorily. If occasionally a tube breaks, it can be replaced with comparatively little trouble without taking the apparatus apart, and the quantity of acid lost is trifling because there is so little in the apparatus that can run out.

When working steadily the still is very efficient, a battery of four having a capacity of about 2000–3000 lbs. of distillate per 24 hours, and if facilities are provided for supplying the acid to the stills by gravity so as to avoid unnecessary handling, the labor involved will be a comparatively small item of expense, while the loss in breakage and the cost of fuel is reduced to a minimum. This invention has been patented.

Another system of stills constructed on the same principle of continuous operation and one which has been used for a number

of years by the J. T. Baker Chemical Co., is made entirely of porcelain, and having less joints there is less liability of leakage than in the apparatus above described, particularly where the joints must be made with asbestos, as in the case of nitric acid.

Under certain conditions porcelain will withstand the strain of great heat better than glass, and it has been found feasible to distill acid from porcelain vessels of considerable size without danger of breakage. An apparatus of this construction is illustrated in Fig. 3 (which by the way also illustrates a condensing system to be referred to later)

The vessels measure about 3 ft. in length by 8 ins. in width and

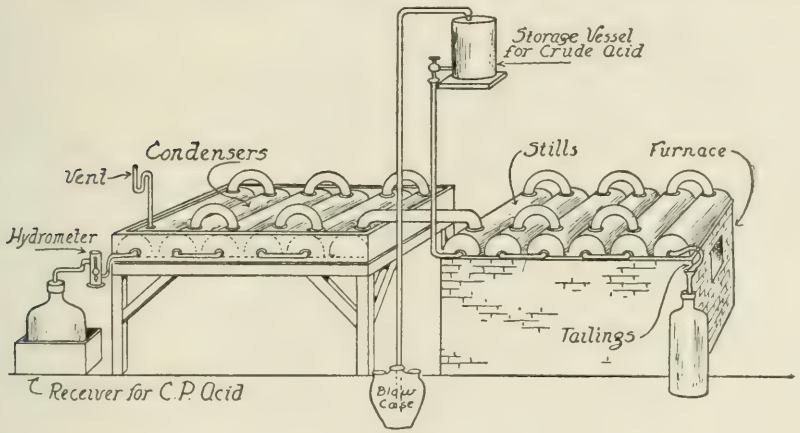


FIG. 3.

are flat on the bottom in order to obtain a large heating surface. A number of vessels, say 10, are laid side by side on top of the furnace directly over the firebox and are connected together with small glass tubes near the bottom to conduct the acid through each vessel in succession and with porcelain goose-neck pipes for the passage of the vapors. The large extent of heating surface which the vessels afford makes the apparatus a very efficient still without forcing the fire and running the risk of cracking the porcelain, which owing to the size and nature of the ware has comparatively thick walls. In order to avoid condensation in the stills owing to the radiation of heat from the upper surface, the vessels are protected with a covering of asbestos. The joints are packed with rubber gaskets for hydrochloric acid and with pure asbestos fiber for nitric acid.

The crude acid is first elevated by air pressure from a blow case located where it can be filled conveniently, to a storage vessel overhead from which it runs by gravity into the stills, the flow being regulated by a cock so that there will be a slight overflow of the tailings at the farther end of the system. The capacity of the still is about 2500 lbs. hydrochloric acid and 4000 nitric acid per 24 hours' continuous running.

The condensation of acid vapors on a large scale was also a serious problem, for an efficient condensing system is absolutely

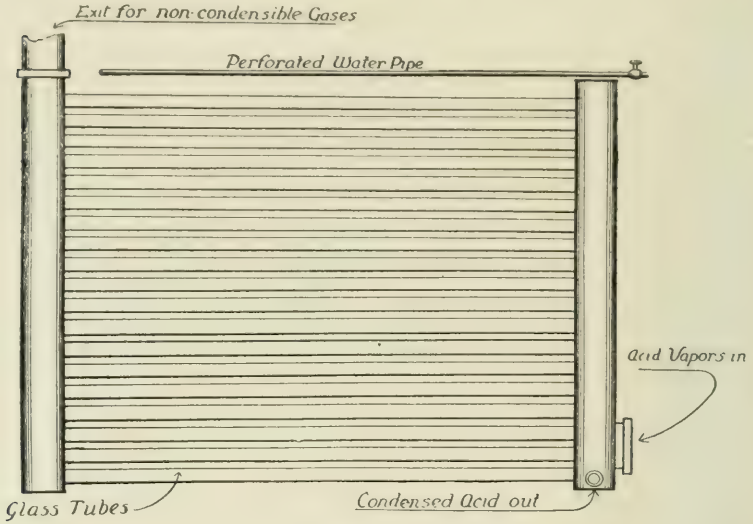


FIG. 4.

essential to the successful working of any still. One of the first efficient condensers invented and patented was constructed of glass tubes, and as illustrated in Fig. 4.

It consists of a number of glass tubes 6 or 7 ft. long by 1 in. diameter, and two so-called stand-pipes made of earthenware or porcelain (the latter especially for C.P. acids), each about 4 ft. long by 4 ins. diameter, having a row of holes along one side as close together as possible and of a suitable size to receive the glass tubes without binding. The stand-pipes are placed in an upright position and securely fastened in place, having the rows of holes facing each other and at a distance that will allow the tubes to enter far

enough to enable the joints to be tightly packed. The acid vapors enter through an opening in the side of one of the stand-pipes and is divided in its passage through the tubes in which the condensation is effected by trickling cold water of the surface of the tubes supplied from a perforated water pipe placed just above the topmost tube; the water trickles down over each tube in succession and becomes so hot before it reaches the bottom that much of it evaporates, thus increasing the efficiency of the condenser, and what does not evaporate is caught in a trough and carried off. The glass tubes are subjected to the extremes of temperature where the cold water first strikes, but with a good quality of glass they stand the strain remarkably well, although breakage is not infrequent.

Condensation may also be effected without the use of water, as the heat radiates to considerable extent and causes a current of air which carries off the heat by contact. The cooling effect of the air is of course not as effective as that of water, but this deficiency may be made up by increasing the number of tubes. This also removes the danger of breakage experienced when using water, but on the other hand it increases the number of joints and the liability of loss from leakage when asbestos is used as a packing.

This condensing system, known as the Hart condenser, from the name of the inventor, has been in successful operation during a number of years as a condenser for both nitric and hydrochloric acids with certain modifications to suit the peculiarities of each acid, which will be referred to later.

The condensing system used by the J. T. Baker Chemical Co., is made entirely of porcelain vessels and is illustrated in Fig. 3, previously referred to. The vessels are made practically the same as the porcelain vessels used as stills and are connected together in the same manner for the flow of the acid and the passage of the vapors. The condensation is effected by immersing the vessels in a bath of running water, the flow of the water being regulated so that the water surrounding the vessel into which the hot vapor from the still is entering will not be subjected to too great a change of temperature, otherwise breakage is liable to occur owing to the size of the vessel and the thickness of the walls. There are comparatively few joints to cause trouble from leakage, and they are easy to get at and keep tight. They are used for condensing both hydrochloric and nitric acids with some modifications to suit the

peculiarities of each acid, the *modus operandi* of which will next be described.

The distillation and condensation of hydrochloric acid present difficulties which are peculiar to the acid itself and give rise to problems different from distillation processes in general. This is due to the fact that the concentrated acid does not distill at a uniform degree of strength nor at a uniform temperature. The strongest acid commences to distill at a very low temperature and gives off at first dense fumes of dry HCl gas which are uncondensible and must therefore be absorbed in water or in a weaker acid. As the distillation proceeds the temperature rises and the strength of the distillate as well as the remaining liquid decreases until both reach a strength of about 1.10 sp.gr. after which the strength of both, as well as the boiling-point remain constant.

The weaker grades of acid must therefore be again concentrated by saturation with the gas from subsequent distillations, and as the absorption gives rise to heat, it becomes necessary to change the receivers frequently and allow them to cool in order that the final saturation may be made at a temperature low enough to insure the proper degree of strength. This was the old method of distilling, and, as it was necessary to use comparatively small stills, generally flasks of two or three gallons' capacity, each one connected with a small Liebig condenser, and receivers of about the same capacity, the process involved much labor and was far from being economical, particularly when attempting to work on a large scale.

These difficulties were all successfully overcome when the continuously operating system, was introduced. In this system the distillation of the strong and the weak acid takes place at the same time and the different strengths passing into the condenser together at once recombine, the gas being absorbed in the liquid simultaneously as the vapors condense, and the acid when it finally leaves the condenser will have the same strength as the acid entering the still. In the first vessel of the distilling system into which the fresh acid enters there is presumably a slight ebullition and dry gas given off, while from each succeeding vessel down to the last ones situated directly over the fire there is more or less moisture given off with a corresponding decrease in the strength of the tailings, the weakest being about 1.10 sp.gr.

In the first vessel of the condensing system into which the vapor

enters (referring to the system illustrated in Fig. 3), only the weakest vapors condense while owing to the temperature of the water surrounding the vessel being almost the same as that of the vapors, the gas passes on into the cooler vessels where it is absorbed by the liquid flowing slowly through them, until in the last vessel which is thoroughly cooled the gas is all absorbed and the liquid at the same time saturated. The acid runs by gravity from the last vessel through a jar containing a small hydrometer and enables the operator to keep watch of the strength, which varies according to the proportion of tailings drawn off. The distillate is usually a little stronger than the original acid owing to the removal of the tailings, for the reason that as the acid entering the still contains say 36 per cent HCl, the tailings contain only about 20 per cent, and the difference in the amount of HCl gas is absorbed in the distillate thereby increasing the strength to that extent. Indeed it is possible, by drawing the tailings off faster to bring up the strength of an acid which is two or three degrees below saturation before distillation, but the method is not economical; the best results are obtained by using an acid say 1.18 sp.gr. and drawing off enough tailings to bring it up to 1.19 sp.gr. which is the strength generally required by the trade. About 5 per cent in tailings is sufficient for this purpose and this amount is also sufficient to carry off the impurities fast enough when using ordinary commercial hydrochloric acid.

The impurities commonly found in the commercial acid are principally sulphuric acid, iron, sodium sulphate, arsenic and sometimes sulphurous acid and free chlorine. Before distilling the acid sufficient chlorine is added to oxidize the H_2SO_3 to H_2SO_4, the excess of Cl being reduced by adding some reducing salt in solution. The non-volatile impurities remain in the tailings, and if there is any spurting in the last vessel where they become concentrated or any volatilization of sulphuric acid at this point, these impurities will be retained in the other vessel without danger of being carried over into the distillate. Arsenic compounds being volatile are always found in the distillate, at least in traces, as it is impossible to obtain a crude acid made in the ordinary way from salt and sulphuric acid which does not contain some of this impurity. An acid made synthetically from Cl and H as a by-product in the manufacture of caustic potash at Niagara Falls is free from arsenic and a C.P. acid made by distilling this product after reducing the free Cl, which is always present in great excess, is strictly C.P. Organic matter is difficult to remove

as it appears to form a volatile organic chloride which distills over and gives a yellow color to the distillate, although it can then be reduced and removed by a second distillate.

Hydrochloric acid can also be condensed in a glass tube apparatus similar to one above described (Fig. 4) with some modifications; the tubes instead of being open at both ends are closed at one end and an opening made on the upper side when in a horizontal position placed directly under the open end of the tube above, which is provided with a lip, so that when arranged in alternate order, the liquid will follow from the topmost tube through each tube in succession to the bottom. In this way the vapors which condense in the tubes follow a long and tortuous passage over which the gas passes and is gradually absorbed, while at the same time it is kept cool by water trickling over the outside. This arrangement is illustrated in Fig. 5 where it is described for another purpose. As an apparatus for absorbing gases it is covered by patents.

In the distillation of nitric acid, difficulties are met which are easily overcome by using a continuously operating system similar to that used for hydrochloric acid with some modifications. The impurities commonly present in the crude acid are sulphuric acid and sodium sulphate from the materials used in its manufacture, chlorine and iodine present in the nitrate of soda and hyponitric acid due to a slight decomposition of the nitric acid in the process of manufacture.

The chlorine and hyponitric acid are volatile at a low temperature and will therefore be found in the first part of the distillate; the balance of the distillate will, however, contain some hyponitric due to a slight decomposition of the acid giving the distillate a slight yellow color, which can be removed by heating and subsequent exposure to air. In a continuously operating still, such as either of those above described, the volatile impurities are separated by conducting the vapors from the first vessel or two to a separate condenser from that in which the vapors from the remaining vessels are condensed, and instead of allowing the acid to leave the condenser cold, the latter is constructed so that the acid is drawn off hot in order to bleach it without subsequent heating. This is accomplished when using the glass tube condenser, by giving the tubes a slight inclination towards the stand-pipe into which the hot vapors are entering, and when using the porcelain vessel system, by inclining the bath and reversing the flow of the condensed acid back into the first vessel, in each case forming a sort of reflux condenser. The

hot acid thus obtained is led through a bleaching apparatus which also serves as a cooler to reduce the temperature and avoid cracking the receiving vessel. This apparatus is illustrated in Fig. 5. As previously described it consists of a number of glass tubes constructed so that the acid flows successively through all the tubes and being thus exposed to the air which is carried along with it, the hyponitric acid is oxidized and at the same time the heat is absorbed by trickling cold water of the outside of the tubes in the usual manner. Furthermore if the acid is above standard strength (sp.gr. 1.42) as is generally the case when the crude acid is made solely for redistilling, the strength may be reduced by adding a calculated quantity of distilled water

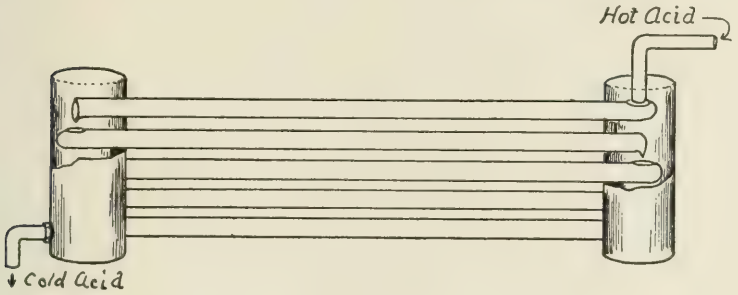


FIG. 5.

while it is running through the cooler, which also removes the heat thus generated.

The distillation of sulphuric acid presents a more difficult problem than the other acids on account of the high temperature at which it boils. Glass retorts with very thin walls have generally been found the only thing suitable, although it is well known that porcelain vessels have been used in concentrating chamber acid by distilling off the water and bringing it up to a strength somewhat below complete concentration, a process which of course does not require a temperature as high as the distillation of the concentrated acid itself.

After experimenting for some time, a method for using procelain retorts was devised and a continuously operating system of stills made of this ware is now being successfully used by the J. T. Baker Chemical Co. The stills or retorts are made comparatively small and hemispherical in shape being about 8 ins. in diameter across

the bottom. On each side are tubular openings of suitable size so that the retorts can be connected together by passing the tubular of one retort into the tubular of the retort next to it. Instead of having the retorts on a level as in the other systems, they are laid on an incline as shown in Fig. 6, so that the acid overflows from one retort into the next below, the position of the outlets being such that the acid stands at the depth of about 2 ins. in each retort. The

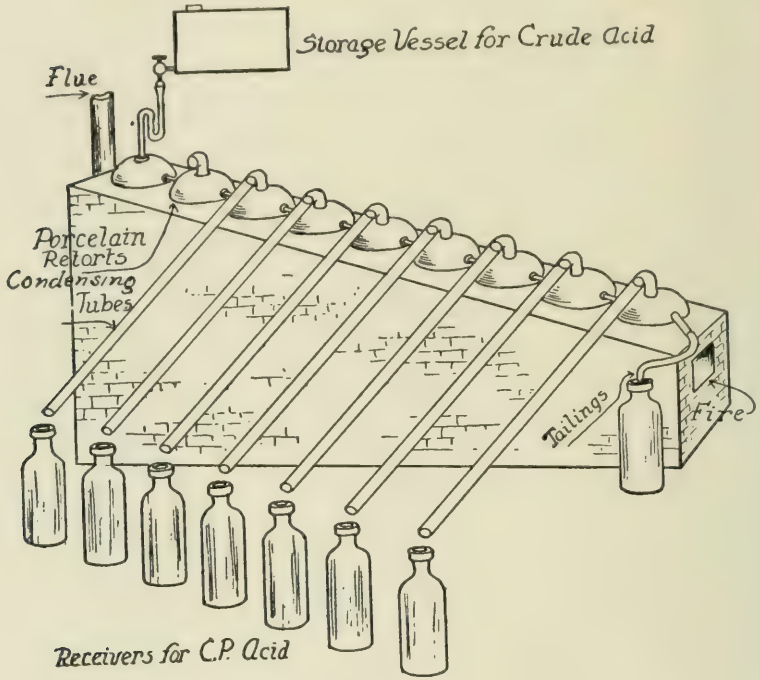


FIG. 6.

joints are packed with asbestos to prevent the escape of the vapors, and the upper parts of the retorts are protected with non-conducting material to prevent the radiation of heat.

The fire is located at the lower end of the furnace with a long inclined flue over which the retorts are laid and the waste heat utilized for bringing the acid up to the boiling-point before it reaches the point where the distillation takes place. A number of retorts can be placed on one furnace, and from about half of them nearest

the lower end concentrated acid will be obtained, the others giving acid containing more or less water. The crude acid is supplied in a steady stream and is regulated so that there is a constant overflow of tailings from the last retort.

The impurities in crude sulphuric acid are principally sulphate of lead and sulphate of iron and if present in any great quantity will give trouble by forming incrustations on the bottom of the retorts and cause bumping and breakage, unless the retorts are cleaned out at regular intervals of four or five weeks' steady running.

The condensation of sulphuric acid vapors may be effected in glass tubes without using water to absorb the heat provided the tubes are long enough, say 7 ft. long by 1 in. diameter. Owing to the high temperature of the vapors the strain on the glass is very great but with a good quality of glass having very thin walls this method of condensation has proved quite successful in the past, notwithstanding that breakage was a frequent occurrence particularly in cold weather. The condensation, however, was seldom complete and there was more or less escape of acid fumes from the ends of the tubes, while the temperature of the condensed acid was very little below the boiling-point, so that the receiving vessels, which were necessarily made of glass, were frequently cracked. The constant escape of irritating fumes and the danger to the operator from handling the hot acid added to the difficulties which made the problem of condensation a serious one.

The introduction of fused silica ware has helped to solve this problem, for owing to its great resisting power to changes in temperature, it is possible to use silica tubes in place of glass and sprinkle them with water. This not only effects a complete condensation of vapors but reduces the temperature of the distillate to a point at which it can be handled with perfect safety.

Discussion

Prof. Edward Hart:

I think I have a right to feel some pride when I look over this audience and see how many men here have made good out of the little tuition that I was able to give them. Mr. Baker is one of these men. I was associated with him in this work from the time he took it up and we worked together for a long time. I am the more interested since I see that he has described a number of patents here that were taken out in my name, which I have never described

myself. Mr. Baker has spoken of the glass flasks which we found very unsatisfactory since they broke frequently and required a great deal of coal. In consequence of this I devised the hanging test-tubes, which he has described, and we found that one-sixth of the coal formerly used was sufficient.

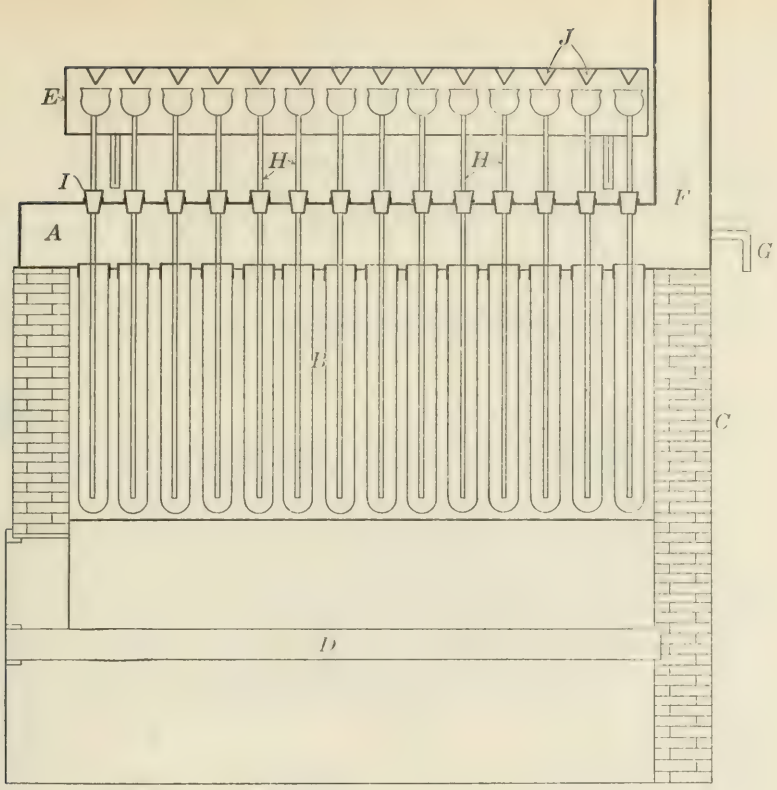
I would like to point out to Mr. Baker that the apparatus which he has shown, made of porcelain, would probably not be so economical of coal as my apparatus with the hanging test-tubes. I should be glad to know how his coal bill compares with ours. Mr. Baker is probably not aware that a patent for a modification of the hanging test-tubes has been applied for which is an improvement on the old form. In the old form the circulation in the tubes was very poor so that sulphate of soda was apt to accumulate and finally break the tube; but this was obviated by the modification shown in the sketch (Pl. 45a) in which *A* is the acid receiver, *B* the hanging tubes, *J* a trough for the supply of acid and *H* thistle tubes feeding the acid to the bottom of the hanging test-tubes. The object of the introduction in this way is obvious, since the fresh acid is fed to the bottom of the hanging tube and the strong residues containing the sulphate of soda are forced out through *G*. In case of hydrochloric acid the stoppers *I* are made of rubber.

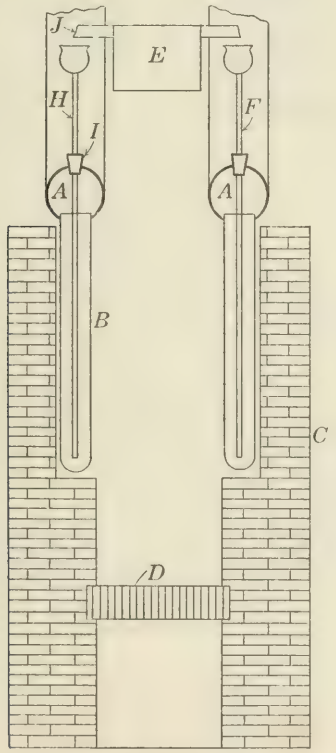
Dr. F. W. Frerichs:

In the last twenty years I have manufactured large quantities of C. P. acids, using 5-gallon glass retorts, each retort set in a small iron kettle. Nitric acid simply was distilled. Hydrochloric acid was distilled from crude acid after treating it in such a manner that free chlorine and sulphurous acid would not contaminate the product. We would obtain, at the end of the distillation, a very weak acid which was condensed in large 5-gallon glass receivers, and we ran water over the body of the receivers to effect cooling. Taking weak hydrochloric acid from one operation and saturating it with hydrochloric acid gas coming off first in the following operation, we obtained strong acid. For the manufacture of C. P. sulphuric acid, we bought weak sulphuric acid 20° Bé. coming from platinum stills. Strong acid was obtained by evaporation of pure weak acid. This was a very slow process, but I made upwards of 200,000 lbs.

Mr. Baker:

I appreciate Prof. Hart's remarks and feel that I owe it to him to say that my inventive genius was stimulated by the association





A - Acid Receivers.
B - Acid Tubes.
C - Brick Furnace Walls.
D - Grate Bars.
E - Crude Acid Trough.
F - Vapor Exit Pipes.
G - Residue Syphon.
H - Thistle Tubes.
I - Stoppers.
J - Overflow Feed Troughs.

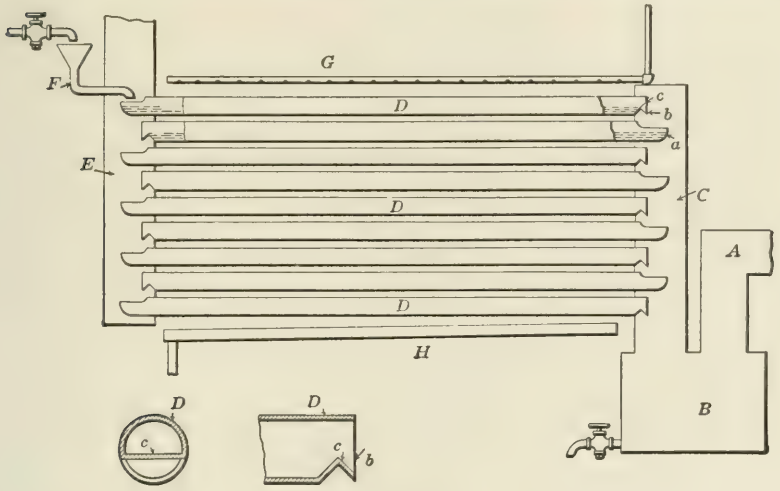
PLATE 45*a*.—Improved Apparatus for Distilling Acids.

[*To face page 344.*]

I had with him. While I appreciate this, and I believe it is a very excellent form of still, I was compelled, owing to the fact that this was covered by patents, to make a substitute. Porcelain stills make a very good substitute.

Prof. HART:

I want to call attention to a device of Mr. Adamson for the absorp-



EXPLANATION

A: Acid Gas Inlet	*G*: Sprinkler
B: Acid Receiver	*H*: Waste Water Trough
C: Stand Pipe	*a*: Condenser Pipe Trough
D: Condenser Pipes	*b*: " " Spout
E: Stand Pipe	*c*: " " Dam
F: Inlet for Absorbing Fluid	

PLATE 43.—Acid Condenser (Hydrochloric), Hart-Adamson Patent.

tion of hydrochloric acid which is quite as ingenious as anything Mr. Baker has referred to.

The arrangement of condensing tubes in this is mine. The little dam made in the end of the tube shown on the plate (Plate 43) is Mr. Adamson's invention. By this simple device the liquid is retained in each tube for some time, allowing a much more perfect absorption than could otherwise be had. We have found this a very efficient apparatus.

Mr. Baker:

I did not pay much attention to that, but it is illustrated in one of these drawings (No. 5), what Prof. Hart refers to as a protection on the upper part of this tube, so that the tube is thus kept partly full. The first method of distillation I referred to was the old method of using retorts such as I have described here; the stronger and weaker vapors are going off all the time.

Mr. Minor:

Is there any preheating of the acid?

Mr. Baker:

Well, it is not really necessary. It is merely preheated by being in the flue of the fire. The fire does not cover the entire portion of the still. The fire will probably be in the first part and the other tube will be in the flue. We used that in distilling nitric acid, because it could be distilled at a low temperature.

COMBUSTION OF PULVERIZED COAL

By L. S. HUGHES

Read at the Washington Meeting, Dec. 20, 1911

A PROBLEM of importance both from the standpoint of current expense and the larger aspect of conservation of mineral resources is the utilization of the wastes of coal mining. The fine coal is lost to some extent at the mine and to a much greater extent at the point of consumption where screened coal is employed.

The obvious remedy for this waste is the burning of the coal as a powder and this process has been the subject of an enormous amount of experimentation; not only because it offered a means of saving wastes but also, and indeed chiefly, on account of the advantages indicated by obtaining complete combustion and employing a mechanical feed.

As is well known, powdered coal injected by an air or steam blast burns with furious energy, and, properly controlled, yields no smoke. The fact that combustion can be completed within the firebox and that there are no heat losses through incomplete combustion offer such marked desirability that the claim has been made that fuel cost can be reduced 50 per cent by the use of powdered coal. This estimate may be excessive, but there is no doubt that a very great saving can be secured.

From the engineering end of the question great ingenuity has been displayed in devising automatic feed hoppers and combined pulverizers and injectors, but the numerous attempts to introduce this practice have resulted in practically universal failure with the exception of kiln firing. This field, compared with that of steam making, is of course very limited. While some failures undoubtedly have been due to faulty apparatus and bad installation by far the greater number have resulted from a destruction of the firebox and crown sheet. Very persistently the same ground has been gone over again and again with the same result; bricks and steel both "melted" little by little.

Quite naturally this appearance of fusion has been regarded as an evidence of too great heat and the real cause of trouble has been in most cases unsuspected.

Considering how nicely a coal jet may be regulated to meet the heat demands it is obvious that there has been at least an oversight in coming to this conclusion.

In some cases where marked reduction of the fuel was tried actual destruction of the firebox did not result but another almost equally objectionable feature appeared: the coating of grate bars, crown sheet and walls with a vitreous, adherent c ating of slag or clinker.

As this coating of fused silicates bore a manifest relation to the slags produced in blast furnaces it appeared probable that it might prove subject to a simple control by the application of the same means as are employed for the control of the fusibility of furnace slags. It was perfectly evident from the most cursory examination that the fused ash or clinker was the active agent of trouble even where destruction of the firebox occurred; the finely divided ash, intensely heated, coming in contact with the surface of iron oxide covering the steel, must form a complex silicate in which the iron oxide took a place with the resultant formation of a ferrous silicate or complex silicate containing ferrous oxide yielding a compound of even lower melting-point. Indeed the easy fusibility of silicates containing much ferrous oxide is a factor of great importance to the lead smelter who designs his blast furnace slag upon that basis.

In the matter of the destruction of the firebrick another phase of the elasticity of silicate limits was apparent. Assuming the firebrick to be high in silica the molten ash would combine with it to form a highly acid complex of silicates, a condition also tending towards ready fusibility.

The formation of a residue which would prove infusible under the temperature conditions of the firebox proved to be a very simple matter. Its solution could be attempted by taking advantage of the fact that silicates high in alumina are difficultly fusible or the more attractive behavior of silicates carrying an excess of the lime group. The latter was regarded as preferable because of the much greater reactivity of the earth oxides.

It was recognized that the simplest way of securing maximum reactivity was to employ the basic oxide in *statu nascendi* by introducing it as a carbonate and allowing the heat of the burning coal to decompose it.

As experimental demonstration of the feasibility of application of this principle resulted so satisfactorily that it seems odd that so simple a remedy for a serious difficulty had been overlooked. No difficulty whatever was encountered. A simple air blast injector fed the coal into the firebox and a small amount of limestone, roughly equal in weight to the ash of the coal, was introduced with it. Immediately the character of the ash formed changed from a sticky shower of molten particles which was rapidly corroding crown sheet and brick to a dry, pulverulent dust which displayed no tendency to cohere or clinker in any way.

In practice the most satisfactory application is the employment of a combined impact pulverizer and injector into which the unpulverized coal and limestone are fed and pulverized together. Very good apparatus of this type is already on the market, having been developed for kiln firing, and can be used without change for burning with limestone.

Theoretically, of course, an advantage would be secured by employing in place of the limestone a dolomite or more preferably a magnesite on account of the more marked decrease in fusibility occasioned by the addition of magnesia and also because a smaller amount could be employed. Dolomite, however, is in most instances much less friable than calcite and magnesite is comparatively expensive. From a practical standpoint the calcite answers every purpose.

THE DISTRIBUTION OF POWER IN PORTLAND CEMENT MANUFACTURE

By RICHARD K. MEADE

Read at the Washington Meeting, Dec. 20, 1911

In the manufacture of Portland cement, the question of power enters quite largely. In the manufacture of 3000 barrels of cement per day, there must be ground approximately 1650 tons of material to an almost impalpable powder every 24 hours. Nine hundred tons of this represent the raw material which must be reduced from pieces of stone as large as a man can handle to such a degree of fineness that from 90 to 98 per cent of the powder will pass a 100-mesh test sieve. Six hundred tons represent the slag-like clinker which must be pulverized so fine that at least 92 per cent of it will pass this sieve, while the remaining 150 tons consist of the coal for heating the kilns, which is pulverized to about the foregoing degree of fineness. The power required to run this amount of machinery is probably greater than that which would be utilized in the manufacture of a similar value of any other commodity.

In addition to running the machinery necessary for grinding, power is required in quarrying and transporting to the mill the raw materials, in operating the elevators and conveyors used to handle the product in the various stages of its manufacture, to revolve the kilns and to keep moving various minor operations of the process.

The size of the power plant which will be required in manufacturing 3000 barrels of cement per day will depend largely upon the class of material to be ground, upon the type of machinery used to do this, the degree to which it is done, as well as the proper installation of the plant itself and the means of transmitting the power to the machinery.

The general character of the power generators themselves and the arrangement of the engine and boiler rooms is similar to that

of other manufacturing enterprises where much slow-moving, heavy machinery is operated. Cross compound condensing engines of the Corliss type are generally employed, although in electrically driven mills the steam turbine has been used successfully; and, where natural gas is available, gas engines are often employed.

The steam plant usually consists of water tube boilers. These are generally of the horizontal type, but, occasionally, vertical boilers are employed. At one or two mills the boilers are arranged to utilize the waste gases from the kilns in making steam, but this installation has never proved very satisfactory.

The transmission of power may be effected by either shaft or electrical drives, but, in either event, the distribution of the power to the mills must be effected with the least possible loss due to friction. When the transmission is non-electrical short powerful shafts are used which are driven by belting or rope drives, directly from the engines, and which in turn transmit the power to crushers and grinding mills.

In designing the power plant of a shaft-driven cement mill, it has usually been found best to run the mills grinding raw material with one engine and those grinding clinker by another, rather than to use one large engine for both. It has also been found best to run the kilns by a separate engine so that shut-downs may be avoided; and often here, too, the outlying machinery will be driven by means of a generator and motors.

The electrical transmission of power is now considered best for cement mills for a number of reasons: First, it permits of a better arrangement of the buildings both as regards future extensions and the bringing in of supplies; secondly, as each machine is run by a separate motor, the plant is not affected by the shutting down of any particular machine and the operation is more continuous; third, the steam turbine, a very economical prime mover, can be installed; fourth, the upkeep on motors is less than on line shafts; fifth, the economy under varying loads is greater. It is generally conceded, however, that where the mechanical transmission is a good one it is more economical of power, but the foregoing advantages are now considered to offset the greater steam economy of the mechanical system, which latter is seldom good. This is owing to the fact that an installation of tube mills in a plant of any size requires much counter shafting or else their being run with a bevel gear, while Fuller mills and Griffin mills require a quarter-turn

belt. For this reason the line shaft system is seldom placed at an advantage.

In the electrical system, the engines are connected direct or by belting to powerful alternating-current electric generators and the current from these is carried about the mills by copper cables and distributed to motors which are directly connected sometimes by gearing but preferably by belting to the mills. Usually two or three engines of equal power are employed rather than one large one, on account of shut-downs. Where water-power is at hand the generators are connected to powerful turbines and power thus very cheaply obtained.

One of the defects of mills actuated by horizontal pulleys, such as the Fuller-Leigh mill and the Griffin Mill, has consisted in the necessity of driving them with a quarter-twist belt. In the new plants employing these mills this has been done away with by the use of vertical motors. Practically all of the newer mills have adopted the plan of driving their kilns and machinery in outlying buildings by means of individual motors, even where the rest of the plant is shaft-driven. In such a plant about 25 per cent of the power is transmitted electrically.

In the new plant of the Tidewater Portland Cement Co., Union Bridge, Md., not only the kilns, crushers and grinding machinery are motor-driven, but also the conveyors are so operated. Each conveyor and elevator has its *own* individual motor, doing away with practically all shafting in this mill.

Alternating-current generators and motors are now almost universally employed in cement mills, as these are less affected by dust. The voltage employed is usually 500 to 600.

A few of the western plants have been able to make use of cheap hydro-electric power in their grinding. In practically all cases the power has been purchased from some large outside corporation developing waterfalls. Among the mills at which this has been done may be mentioned the Santa Cruz Portland Cement Co. and the Cowell Portland Cement Co., both of California, and the Superior Portland Cement Co., of Baker, Wash. At some of the Kansas plants, gas engines have been installed, using natural gas for power. These mills also use natural gas for burning.

At the new plants of the Universal Portland Cement Co., a subsidiary concern of the United States Steel Corporation, the waste gases from the blast-furnace are used to generate the power required

for cement manufacture. The gas engines are located at the furnace and are connected to generators. The power is transmitted some distance in each case to the cement mill. A separate motor is used for each machine.

Ordinarily, the actual amount of power required in the manufacture of Portland cement is considered about 24-horse-power hours (or 1 H.P. day) per barrel of cement produced; or, in other words, to manufacture 3000 barrels of cement per day, 3000 horse-power equipment will be needed. The actual quantity varies, as we have said, with the hardness of the raw materials and of the clinker and also with the engineering skill with which the plant is laid out with respect to power transmission.

At one of the newest of the electrically-driven plants, recording wattmeters have been installed in the various departments, and by means of these an accurate record is kept of the power employed in the various operations connected with the manufacture of a barrel of cement.

The figures so far obtained show the power to be distributed as follows:

For the air drills in the quarry	2.0%
For the transportation of the stone to the crushers	0.4
For the limestone crushers	1.8
For the shale crushers	0.1
For the dryers	1.8
For the raw ball mills	5.2
For the raw Fuller mills	21.8
For the kilns	5.9
For the coal mill	4.2
For the clinker ball mills	2.0
For the clinker Fuller mills	43.2
For the shipping and packing department	1.4
For the loss, lights, etc	10.2
	100.0

In the above table, there is included in the power for each step that required to convey the material to the next. This accounts for the high percentage of power required by the kilns, as some of this power is utilized in conveying the clinker into

a large clinker storage and bringing it out from this to the clinker mill.

In this plant, the raw materials consist of a soft limestone and shale. Gyratory crushers are used to reduce the material to sizes suitable for the ball mills and these latter are employed to prepare for the Fuller mills. Both the raw materials and the clinker are ground to a fineness of 96 per cent, passing a 100-mesh sieve. The clinker may be classed as difficult to pulverize, as it is always burned hard in order to secure high quality.

By referring to the table it will be seen that 30.7 per cent of the power is required to prepare the material for the kilns and 45.2 per cent for the pulverizing of the clinker. The other 23.1 per cent is employed in the minor departments and represents also the losses in transmission lines, etc.

The distribution of the power among the various departments depends, of course, largely upon both the installation and the materials to be ground. From a ball and tube mill plant the following figures are obtainable:

Crushers and dryers	5.6%
Raw material pulverizing	29.8
Kilns	7.0
Finishing mills	39.6
Coal mill and miscellaneous	18.0
	100.0

With very hard raw materials the power required to prepare these for the kilns has risen to 50 per cent of the total power employed, but usually this department takes a little under one-third of the total power, and the clinker mill slightly more than this.

Roughly speaking, we should be able, on an average, to prepare material for the kilns at an expenditure of between 15 and 20 KWH. per ton; or, from 5 to 7 KWH. per barrel of cement produced. For the operation of the kilns and dryers, including the pulverizing of the coal for the former, about 2 KWH. per barrel of cement should be sufficient, while, for the reduction of the clinker to cement, a final 7 to 10 KWH. will be required; or, in all, from 14 to 19 KWH. (or 0.78 to 1.06 H.P. day) per barrel. Rating a KWH. as equivalent to about 3 lbs. of ordinary steam coal (=40,000 B.T.U.), a barrel

of cement would represent from 42 to 57 lbs. of coal for power and from 80 to 100 lbs. for burning, or, from 122 to 157 lbs. in all.

The question has been raised as to the advantage of employing the wet process for burning, thereby securing a more easily ground clinker. It is also claimed that the wet process allows the raw materials to be more easily ground. The wet process, however, increases the fuel required for burning at least one-third, or 30 lbs. at the lowest. As this quantity of coal is usually rated in practice as about equivalent to 10 KWH., or almost as much power as is required to grind both the raw materials and the clinker, the wet process, on the score of power economy at any rate, does not seem to promise much.

A careful analysis of the power question, particularly where fuel is cheap, would seem to indicate that it is much more important to consider grinding machinery with a view to repairs and attendance than with a view to saving of horse-power. Of course, all things being equal, the saving of horse-power is essential, but in choosing machinery, economy of upkeep is fully as important as economy of power. A KWH. will usually cost about half a cent to generate, and will often cover the range of power per barrel between the various types of well-known pulverizers used in the cement industry. It may not, however, cover the difference in cost of repairs, etc. An analysis of the cost sheets of most cement plants will show the cost of attendance and repairs in the raw and clinker grinding departments is fully as high as the cost of the power delivered to them. For example:

Cost of Raw Grinding Department

	per bbl.	
Operating labor	2.55 cts.	
Repairs	2.44	
Supplies	0.04	5.03 cts.
Power		3.09
Total		8.12 cts.

Indeed, the cost sheet of the average cement mill will show repairs to be a larger item than power. A good example of this is the following:

	per bbl.
Operating labor	$0.20
Repairs	.10
Kiln coal	.103
Power	.082
Packing	.034
Office, laboratory, etc	.016
	$0.535

These data are taken from the books of a highly successful new mill and the figure obtained is achieved only by very careful and efficient management. The figures for power and repairs may both be considered low and serve well to show the relative relation between the two items.

In selecting the type of machinery to be installed in a cement plant, therefore, it is not sufficient to consider merely the relative power consumed by the different types, per barrel of the product obtained, but also the repairs. The mechanical engineer has often shown a tendency to make selections based solely on power efficiency tests made in the machinery manufacturer's experimental plant, only to find out on actual operation that the cost of repairs more than offsets any saving in the coal bill.

Discussion

The President:

Is there any discussion on this paper?

Dr. McKenna:

Mr. Meade would increase the value of that paper if he could give us figures of the power consumption in the other types of mills, at least the class where the tube mill follows the ball mill. It appears from his paper that where the ball and ring type of mill is used 77 per cent of the power is used in the grinding process, which shows just where economies can still be made, although that is quite a wonderful record, I think. But I would like to know his opinion as to what the power consumption would probably be where the tube mill was used. I think we may disagree about it. The power consumption will be lessened somewhat by the use of a wet process, not at all like the old marl process, but one in which the slurry is not any more wet than necessary to move it, because less power

will be required by such clinker, which in my experience is more vesicular and not so easy to break.

Mr. MEADE:

The great trouble with comparing installations is that in order to make comparisions which are of value they should be on the same materials. I have known a tube mill installation where the horse-power ran up to 3600. I think probably the Doctor is right: in the wet process grinding is slightly easier than in the dry process. On the other hand a great deal more coal must be burned for the wet process than for the dry. In comparing the two types of mills you must have them on exactly the same thing in order to judge correctly, and I think most cement men, when the actual time comes to operate the type selected, always wish they had installed the other machine. (Applause and laughter.)

Dr. MCKENNA:

Having obtained the admission out of Mr. Meade that the clinker is probably easier to grind, I think the prospect for economy is good, because the clinker grinding uses 40 per cent of the power. There is a fine opportunity for economy. Then again, there is a saving of the coal consumption in the driers; that must also be taken into account.

Mr. H. O. CHUTE:

It is a very interesting question whether it is better to burn coal to generate mechanical power, or to burn coal and evaporate water from soft or wet materials. The ordinary wet slurry made from marl clay contains, I believe, at least 65 to 70 per cent of water if it is ground in the ordinary way, but other clay industries are now filtering clay and getting the moisture down to 23 or 25 per cent. I had occasion to investigate this point a few years ago, and could not find where anybody in the cement industry had tried to eliminate the water from wet-ground material with a filter-press, whereas other industries have used it very successfully. I fail to see why the cement industry should not grind wet, with a minimum consumption of power and eliminate the water in a filter-press. It is a very cheap press.

The PRESIDENT:

I am not so very familiar with cement manufacture, but if it is necessary to evaporate the water, would it not be possible to make

power with the steam and use the exhaust steam for drying the material?

Dr. McKenna:

I think Mr. Chute misconstrues the process, because the modern wet process is not an attempt to utilize marl. It is an attempt to take hard, almost dry raw materials and grind them wet, saving power in the grinding but keeping the water content down to what that particular material can be moved at, which is as low as 35 per cent.

You must consider the enormous amount of material handled in a 3000-barrel mill—about 2,000,000 lbs. of material per day, and all of those operations must be performed on it. To perform the operation of filtering, even where there is a centrifugal or press, is out of the question. Other forms of separators, like slime separators, might possibly be worked on such large bulks, but they also seem out of the question. The advantage of the moisture is considerable, because we can pour the mass and move it into the kiln, and we still have a surplus of heat there, if we are willing to use it there for that purpose. In this manner we get a disposition of the clinker as it goes down, which is very favorable, and I do not expect to see any attempt made to adopt the filter press, centrifugals, or water separators, where there is such an enormous bulk and the water present so great in amount.

Mr. H. O. Chute:

We can very frequently learn a great deal by going outside of our own fields. A few years ago I visited the Homestead Mines in South Dakota. They are handling 2000 tons of slimes per day, containing $1.80 worth of clay in them, and these slimes are made by a filter press, and save 50 cents a ton. To say that filter-pressing was too costly would indicate perhaps that there are other industries that have reduced the cost of the filter process. It is true at the Homestead mines the slimes are washed out, but there are other mines where the word " pressgate " is used, and I think if you used this press you would not say it is out of the question as a business proposition.

I would like to ask Dr. McKenna if he has ever known of the continuous centrifugal separator?

Dr. McKenna:

They have been promised and promised us, but they always fall down when it comes to a demonstration.

Mr. H. O. CHUTE:

There are some very large piles of clay slimes in the West, which indicate that this work has been done.

Prof. M. C. WHITAKER:

I would like to ask if any interest has been taken in the producer gas power?

A Member:

It seems to me it is a question whether we are going to put the accent on the "chemical" rather than the "engineers." I perfer to put the accent on the "chemical."

The PRESIDENT:

I believe it is one of the objects of our Society to put the engineering part and the chemical part together.

Mr. MEADE:

The question of producer gas has come up often. We gave it quite a little thought when we built our new plant at Union Bridge, and concluded that possibly we had better stick to the old lines. The Universal Portland Cement Co., which is a subsidiary of the Steel Trust, use a portion of the gas from their furnaces. I believe myself in the producer installation. I have talked with a great many engineers about the same thing. Producer gas has not been a success for burning; it has been tried quite extensively. I suppose if they got a gas with a higher fuel value they might be able to use it.

HARDNESS OF PLASTERS AND CEMENTS, AND A SIMPLE CHRONOGRAPHIC APPARATUS FOR RECORDING SET

By Dr. CHAS. F. McKENNA

Read at the Washington Meeting, Dec. 20, 1911

One cannot give a clear definition of the term "Hardness" which shall serve for all the meanings in which it is used. The mineralogist using Mohrs' scale always means by this a measure of resistance to scratching or abrading; the wood-worker means the resistance to cutting; the steel-maker sometimes means by it the resistance to deformation under applied loads; in fact, indentation tests rule in many fields rather than scratching, cutting, or any other form of test.

In the case of hydraulic cements, the first stages of hardening have been usually measured by resistance to penetration; the later stages by finding the increase of cohesion determined by resistance on uniform cross-section to tractive or compressive forces gradually applied until rupture occurs.

The *setting* of plasters and cements is the very first stiffening and rapid development of cohesion up to the stage where needle points under moderate pressures do not penetrate the surface, or where small test objects are easily handled without fracture. Beyond this the phenomenon in which the cohesion due to complex mineral-forming reactions is step by step increased until a considerable age is reached is called the *hardening*.

The chemical phenomena occurring in the setting of plaster of Paris are chiefly those due to the energy in supersaturated solutions. Where a small proportion of water is used a hydrated sulphate of lime of one form goes into solution and the concentration causes the settling out or solidification of another form of hydrated sulphate; the water released from this helps to dissolve more of the first form, which, by concentration, duly deposits again, and thus the process

is continuous to total solidification. Similar phenomena can be observed in super-saturated solutions of some salts, which can be caused to deposit crystals and thicken almost to total solidification. The setting of such a compound of hydrated sulphate of lime is rapid, and except for effects of drying, the maximum hardness is obtained a very few hours after the gauging.

In the setting of hydraulic cements we have something much more complex, though we have been instructed by the case of plaster and by some of the points of similarity in it.

Powdered Portland cement clinker is a complex solid solution of silicates and aluminates rich in lime. When it is wet the alkaline lime solution resulting reacts on the silicates, producing a colloidal mass. A thermal effect occurring here in the beginning is the absorption of heat due to solution or the passing of the solid salts into the ionic condition.

In the setting of cement the first gelatinous mass formed is less and less permeable, due to drawing away of water coincident with the lowering of temperature; then as the crystal formation begins, the proportion of free water momentarily increases again and softens the colloids. Later the full interlacing of crystals and the drying of the colloids admit less and less of penetration, and thus we have the development and finally the end of the process of setting.

Hardening can then go on through further molecular interchanges leading up to the formation of silicates of lime and alumina analogous to some of the hydrous silicates of mineralogy.

According to Michaelis, the exact steps are described as practically a migration of water throughout the mass. The first particles of clinker are dissolved on the surface, the supersaturated lime solution thus formed reacts to form a gelatinous mass, and when crystals of aluminate of lime are formed the water separated goes further to attack newer particles of the clinker nodule, later deserting the colloids formed and passing into the air or into the water in which it is immersed.

These reactions are complicated again by the presence of sulphate of lime, which serves to form with the aluminates of lime a double compound of slow-setting qualities, neutralizing the usual effect of a cement rich in aluminates of lime, where the setting is very quick and the development of heat sudden and great. Thus you will observe we consider setting to be consequential upon the formation of both colloids and crystalloids.

Apparatus for observing these changes in the setting process have usually been simple. For expert workers it suffices to use the thumb-nail. With skill and accustomed observation they thus obtain a definition which is as remarkable as the means are simple. Nothing has been developed towards providing means for observing set in plaster of Paris; the contraction and dilatation, however, have been observed by Van't Hoff in a beautifully simple apparatus.*

General Gilmore recommended, for observing set in Portland

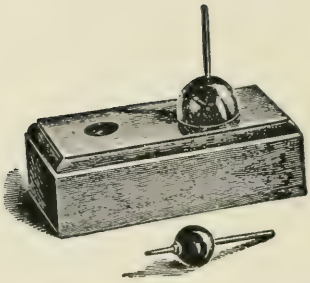


FIG. 1.—Gilmore's Apparatus.

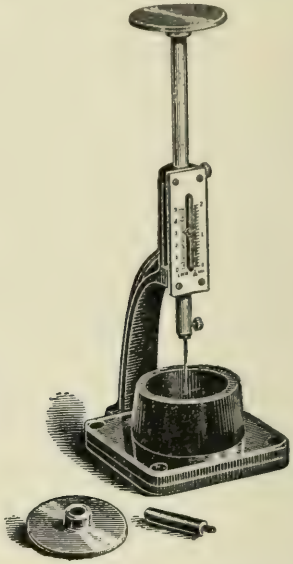


FIG. 2.—Vicat Needle.

cement, a weighted coarse wire and a more heavily weighted fine wire (Fig. 1) for the determination, respectively, of the first stiffening (initial set), and the firm resistance to any penetration or deformation (final set). Neither of these methods is instrumental or fitted to record distinct differences.

The first apparatus designed for such a purpose was that of Vicat, the French chemist and authority on cements. The Vicat needle (Fig. 2) is a weighted one, cylindrical and 1 square millimeter in area on the face, moving in a vertical and scaled-off guide and falling upon

* Z. Physik. Chem., 70, 146.

the mass of gauged cement in the mold below. The initial set is taken as the time at which the needle will not penetrate within a certain

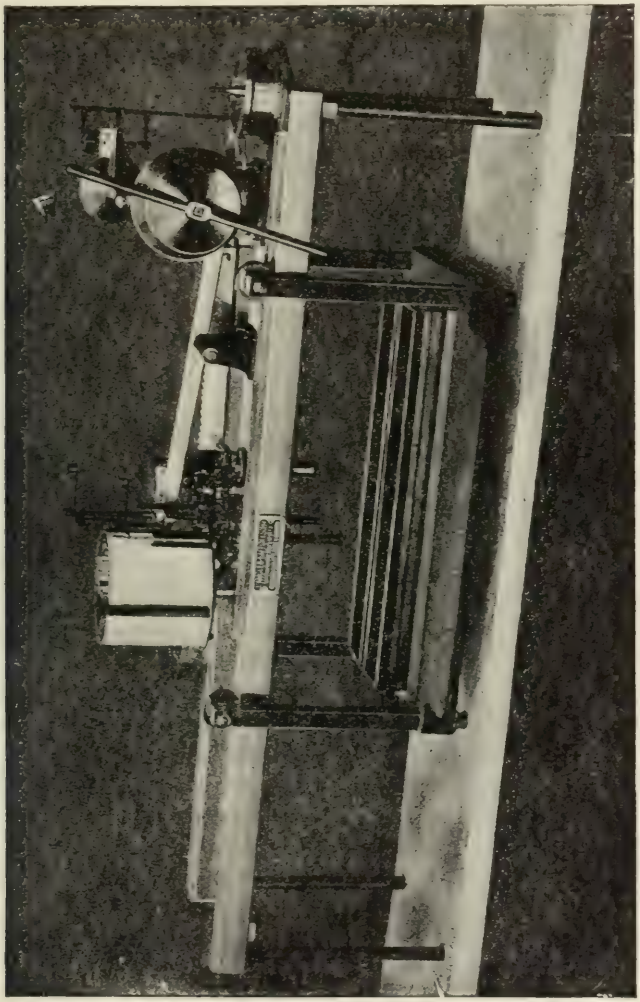


FIG. 3.—Amsler-Laffon Cement Setting Recorder.

distance of the bottom of the mass, and final set as that time when there will be no mark on the surface from the needle.

However, chronographic and automatic apparatus have been sought for.

Professor A. Martens, of Charlottenburg, designed an apparatus in which needles energized by magnets are dropped and raised again as a clock movement makes the contacts.

The Amsler-Laffon cement setting recorder (Fig. 3) has been used

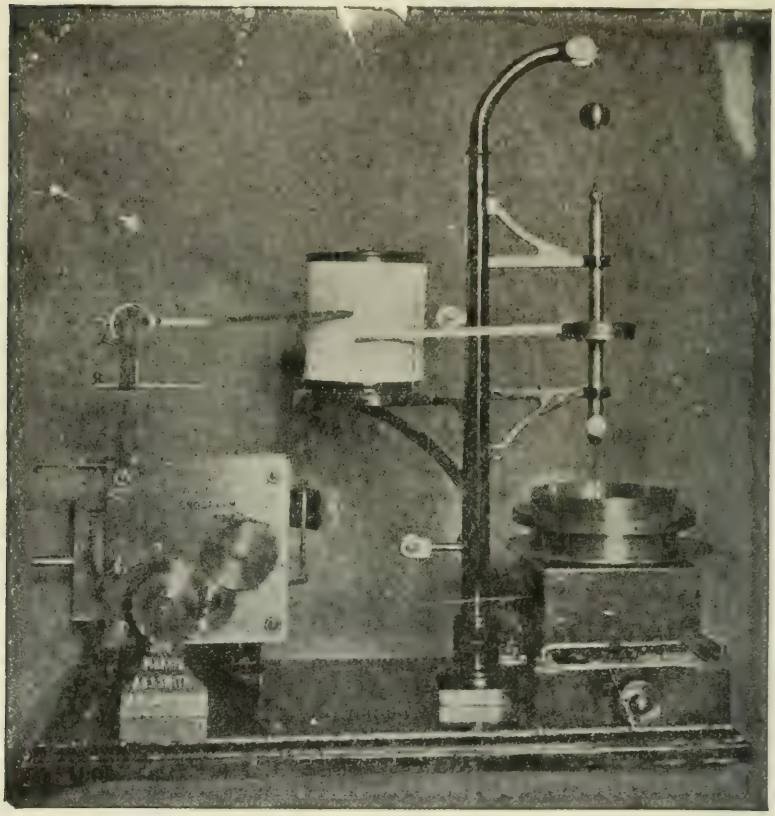


FIG. 4.—Nicol Spissograph.

in Europe. This is described in the journal *Cement*, from which the accompanying cut is taken, and the following description: In testing the activity of cements by this apparatus two molds are filled with a plastic paste and two needles are lowered upon the cement at different intervals, penetrating more or less into the mortar according to the progress of setting. The depth to which each needle

enters the mortar is recorded on a drum by two separate pencils. After each strike of the needles the drum turns a little and the table on which the molds rest advances a step from right to left. The needle holders are lowered and raised by a lever, which is set in motion by a spiral spring; a clock movement lets loose a governor and stops it again when the strike of the lever is completed. The diameter of

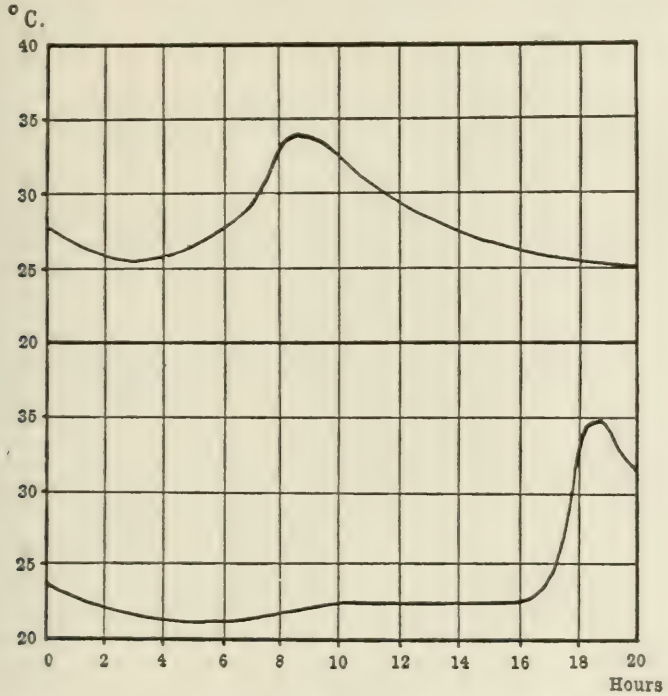


FIG. 5.—Gary's Record of Setting of Cement.

the needle is one millimeter. The weight of each needle holder is 300 grams.

The Nicol spissograph (Fig. 4), the invention of R. Gordon Nicol, of Aberdeen, Scotland, and made by A. & J. Smith of that city, is similarly designed. This apparatus consists of a clockwork which raises and lowers every three minutes a pointed needle; at the same time the paste is rotated in a spiral to present a different spot to the needle at every contact. On the apparatus is a thermograph recording on the same chart the temperature of the air at the time the test

was made. The whole is covered with a glass case and arrangements are made to keep the temperature and humidity regular.

One of the best achievements in this line has been Gary's apparatus and the resulting investigations. He used the thermal changes during setting as the basis of study, and by photographing the changes of the mercury columns secured data for a chart. Such a record as was thus secured, Fig. 5, gives admirable indications of the energy at work. None of these automatic instruments has been used in this country as far as I know.

The following is an extract from the official report of R. Feret, Boulogne-sur-Mer, at the fifth Congress of the International Society for Testing Materials, held at Copenhagen in 1909:

"DURATION OF SETTING

"The use of the Vicat needle continues to be the only practical method in use for the determination for the duration of the period of setting of hydraulic cements. The appliance is of extreme simplicity, but its readings are sometimes uncertain, especially when it is a question of determining the end of the period; besides, the readings are of a purely conventional character and do not appear always to bear a sufficiently constant relation to the duration of the setting period of the mortars of actual practice. The discovery of more exact methods has therefore been attempted. Methods of testing based on the measured variations in the electric resistance of mortars while hardening have not given results of interest.

"Other investigations have aimed at the definition of the setting by the determination of the temperature of the mortar during its continuance. Reasonably regular curves were obtained by this method, which, however, were dependent on the testing conditions and corresponded with chemical phenomena, the relation of which to the change of consistency called setting has not yet been quite clearly established.

"The principal nature of the method to be employed may be the ascertainment of the time, reckoned from the commencement of the gauging, during which a given mortar can, with impunity, be further used without having to be revived by a fresh addition of water or a too violent mechanical treatment."

Reading this I was led to take up again certain studies of setting which I had made some years before, in which I was observing the

resistance to penetration by glass rods, and the resistance to withdrawal of glass threads progressively acted upon by the salts and compounds formed in the paste and operating during the setting process. I thought that the holding power of newly formed salts upon glass might be progressively observed. Also it seemed to me then that the testing of the surface by wire points showed a lack of effectiveness in determining set in colloids and crystallo-colloidal binding agents. Penetration along a plane similar to shear by a knife blade should give better results than mere resistance to rupture of a surface at one point, just as the cutting of metal by a turning tool affords a better test of cohesion than indentation or scratching does.

If several glass rods or pins, ten or fifteen-thousandths of an inch in diameter, are driven into soft paste of plaster or cement, and at intervals are tipped forward, they will cut the mass at first considerably; later to a diminishing extent; and finally when the colloids and crystals are both well formed about the pins (a period corresponding with the final set or resistance to the light wire heavily loaded) they snap off sharply and suddenly. Such a combination seemed to give indications of very fine and measurable differences.

Now if you were to bring up against a line of such pins a glass rod which had been smoked, you ought to get markings on it making a record showing relatively the resistance to penetration.

It seemed to me that this afforded a means of operating a graphic and chronological method, and I have made many models of apparatus for such a purpose by making simple adaptations of things at hand till the present model was developed and put lately into this final form by Messrs. Schneider Bros. of Jersey City, the gifted mechanicians who are known all over the world for the simplicity and beauty of their work on scientific instruments.

I will explain in as few words as I can the operation of this instrument (Figs. 6 and 7). It consists of a screw *H* operated by clockwork, giving two speeds, there being a shifting lever *L* for speed of one inch an hour and another speed of double that. It can also be operated by hand through a knurled head at one end. This screw *H* carries a moving finger *F* projecting over a long rectangular paste mold *C*. This moves forward and strikes successively the glass pins *P* inserted deeply into the paste and projecting vertically from it in one line. As each glass pin bends forward it bears against a smoked glass rod and traces its path until, when a distinct resistance is attained it snaps off. Back of this is an adjusting frame to carry the glass rod,

and this can be brought forward very delicately, or drawn back,

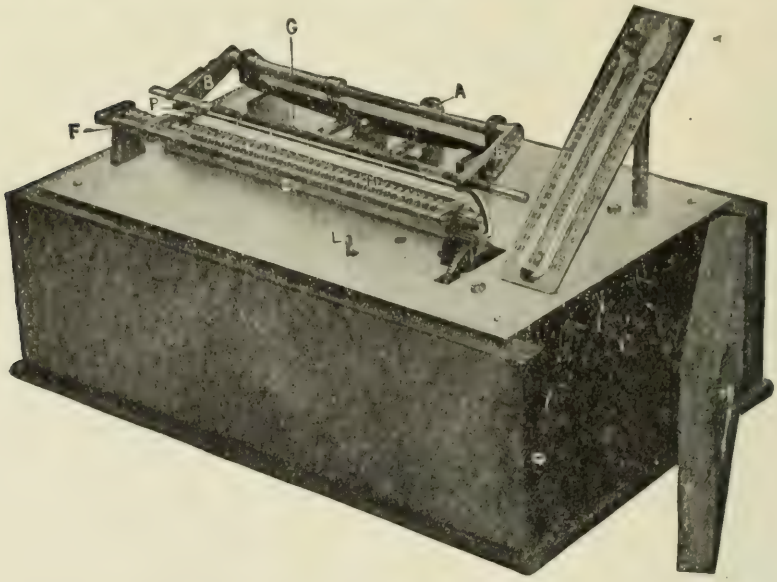


FIG. 6.—McKenna's Chronographic Apparatus for Recording Set of Cements.

by the aid of a fine adjusting screw *A* at the back. A metal mold is filled with freshly gauged cement and run into place between the

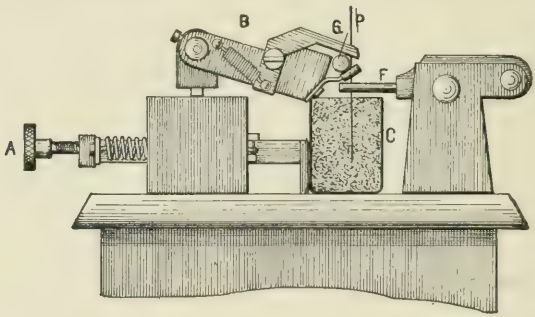


FIG. 7.—Sectional Diagram Showing the Essential Features of the McKenna Chronographic Record.

screw and the adjusting frame. The glass rod, which has been previously smoked and then rubbed clean over one-half of its surface,

is inserted in the frame and brought forward over the center of the paste so that against the clean part of its surface these little pins are guided by it as they are inserted. So far as my investigations have gone I find that fifteen one-thousandths of an inch (.015) give strength enough for meeting resistance and at the same time giving a tendency to snap. They are pushed in vertically along the middle line one-half inch apart; the glass rod is drawn back by the screw *A* and the untouched smoked part is turned over so that it can be brought up against the pins by the screw again, ready for any record. Then the clock is started, the finger begins to move, and as it strikes each pin successively it makes the respective record of the resistance to penetration at that point and time.

A maximum and minimum thermometer may be attached to the base plate.

When everything is thus arranged the top glass case can be put over it, leaving a small dish of water in the case, and the whole left over night. In the morning the entire record is on a glass rod. Records thus made resemble somewhat the markings in Fig. 8.

(The record given for plaster of Paris is not symmetrical as to time, as the legend shows.)

These glass rods, with the records upon them, can be varnished and preserved for examination at any

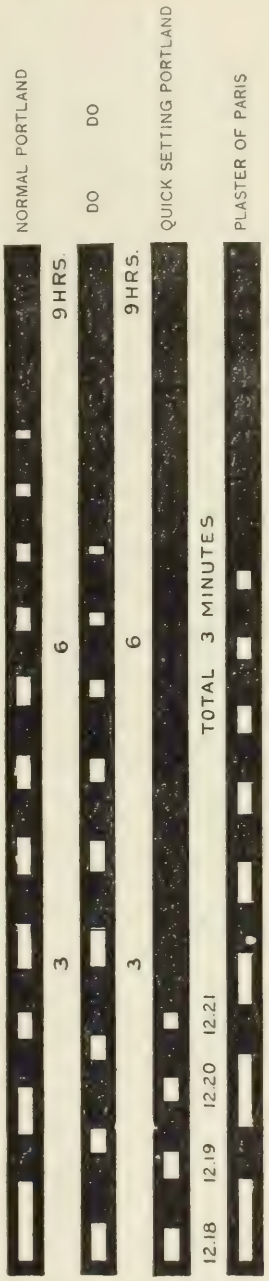


Fig. 8.—Record of McKenna's Apparatus.

time, or the record can be photographed on sensitive paper and thus preserved.

From plaster of Paris I obtained a simple record of differences in resistance to penetration. I have not had many opportunities to experiment with varieties of this substance, but I expect to find that the instrument will readily indicate the differences due to changes in percentages of water, catalytic agents, etc.

From Portland cement the first few records already obtained are most interesting. It seems that in every normal Portland cement I have thus tested there is observable in or about the third hour an indication of a relaxation of the stiffness first obtained and then a resumption of hardening. Comparing these results with those of Gary's thermal studies, it is seen that he observed a marked lowering of temperature at or about the third hour. If we consider again the most modern theories of setting, I think we can explain this. The cooling effect of course is at the period when salts are going into solution most rapidly.

It is well known that if a break occurs in a temperature-solubility curve which is otherwise continuous, it is a proof that the solid substance which is in equilibrium with the solution has passed into another form at the temperature of the break. We have the reverse of this in our record of cohesion, namely, the break in continuity of the marks of increasing cohesion indicates the separating out from a saturated solution of a greater proportion of still another component, and that the water thus freed permeates the colloid and softens it. Later by desiccation, by absorption of the water within and further crystallization, cohesion begins to increase and impenetrability and hardness go on. The discovery of this slack period or reverse set explains contradictions experienced in the past in measuring or determining the initial set by the surface penetration system. It probably also will explain anomalies occurring in the practical use of cement during the first hours of gauging fresh cement.

If this observation of change in the order of setting should prove to be universal for cements with the sulphate of lime additament, we may have to observe first *initial set*, then *reverse set*, and lastly *final set*, and distinguish between them in time and character.

It is my intention to continue work as opportunity presents on this instrument, which appears to be simple and useful, and in time we may hope to reach a little further in our knowledge of the setting of plasters and cements.

THE MANUFACTURE OF GELATINE

By LUDWIG A. THIELE

Read at the Washington Meeting, Dec. 20, 1911

Introduction. The manufacture of gelatine, originating in the remote past, when jelly was produced by boiling calves' feet in the kitchen under the most crude and primitive methods, has now reached such a state of perfection, through the application of Chemical, as well as Engineering Science, that we may justly be proud of the progress of this industry.

To-day millions of pounds of gelatine are manufactured, and it plays a great role in the nutrition of the people.

While the bulk of the gelatine is manufactured for edible purposes, and is used for the manufacture of jellies, jams, candy, ice-cream, etc., products which come under the Pure Food Law, the gelatine used in the arts, for photographic dry plates and papers, for medical purposes in the form of capsules, for bacteriological purposes and for the decoration of fancy goods, does not come under this law; nevertheless, all of these varieties are made in practically the same manner, with like care and precaution, from the most select raw materials, and under the most sanitary conditions which may be applied to such an industry.

The manufacture of gelatine comprises the following distinct operations:

TABLE I

I. Treating and cleaning the raw material.
II. Dissolving the gelatine.
III. Concentrating the gelatine solution.
IV. Chilling and spreading.
V. Drying.
VI. Finishing. (Grinding and packing.)

The most important raw materials consist of

(*a*) Bones (osseine), hornpiths and button bones.
(*b*) Hidestock (calf-pates, trimmings and fleshings).

(*a*) **Osseine.** Osseine is the organic substance contained in the bones, the manufacture of which originated in France.

Raw bones are not used in the manufacture of gelatine at all, but have to undergo a preliminary treatment in order to produce osseine. The treatment of osseine and hidestock is then practically the same. Let us therefore, first consider the preliminary treatment of the bones.

Bones as obtained either direct from the slaughter houses in raw and wet state, or in dried form through dealers, have to be washed, crushed, and degreased in special extraction plants by means of benzine or carbon tetrachloride. In this stage of manufacture, from 8 to 10 per cent of bone fat is obtained from the bones, while the water contained in the raw bones is nearly eliminated. The crushed, degreased bones now undergo the same treatment as the East India crushed bones, which contain practically no fat, consisting in the extraction of the mineral matter by means of dilute acids. This process, called maceration, produces about 60 per cent of acid phosphate, a very valuable by-product. The acids to be used in the manufacture of osseine are either hydrochloric, phosphoric or sulphurous acid, or according to the process of Bergmann hydrochloric combined with sulphurous acid. Until quite recently, the drawbacks attending the use of sulphurous acid prevented its application in the extraction of osseine from bones. In order to prevent the surface of the bones from becoming coated with a layer of tribasic calcium phosphate, it was necessary to keep either the liquid or the bones in constant motion.

In the *Bergmann process* these difficulties are obviated by causing the solution of sulphur dioxide to circulate through a battery of closed tanks in which the bones are treated, the solution being continually enriched by sulphur dioxide as it is neutralized by the calcium phosphate. After having traversed four tanks the solution is still sufficiently acid to retain in solution the whole of the extracted phosphate. The resulting saline liquid is a solution of monobasic calcium phosphate in calcium bisulphite solution. In order to separate the calcium phosphate in the form of dibasic calcium phosphate, and recover the sulphur dioxide, this liquid is heated by

means of steam in a lead-lined autoclave, termed "the digester." This reaction liberates from the calcium bisulphite its sulphur dioxide which is then conducted back to the acid tanks. At the same time, one equivalent of the calcium bisulphite reacts with the monobasic calcium phosphate to form dibasic calcium phosphate, which falls to the bottom of the boiling liquid and normal calcium sulphite.

In order to decompose the latter, an exactly measured quantity of hydrochloric acid is introduced into the digester. The liberated sulphur dioxide is returned to the acid tanks, while the aqueous liquid containing calcium chloride in solution and dibasic calcium phosphate in suspension, is now withdrawn, decanted, and filtered, and the separated phosphate drained on a porous surface and dried. The inventor claims that the so obtained dibasic calcium phosphate is white and pure, and completely soluble in ammonium citrate solution, which is not the case when the phosphates are separated by other methods. The loss of sulphur dioxide in a well-managed factory is said not to exceed 5 per cent of the weight of the bones. The osseine thus freed from phosphate appears to be whiter and of better quality than that obtained by the use of hydrochloric acid entirely, which latter renders the osseine yellow, from which it is more difficult to prepare colorless gelatine.

(*b*) **Hidestock.** Hidestock is received in green, salted, limed or dried form at the factory. It is important in the manufacture of gelatine that the water should be soft, nearly free from lime-magnesia carbonates or sulphates and free from iron.

I. From this stage the process of manufacture of gelatine from osseine, as well as hidestock is practically the same, and the material passes into the first stage of manufacture. The animal matter is introduced into steeping vats, in which it undergoes the process of washing, a treatment with lime or caustic soda in order to saponify the last traces of fat and to swell the material. After liming follows another operation of washing, followed by an acid bath in order to destroy the alkali and bleach the raw stock. From the steeping vats the thus prepared raw material passes into the washmills to be washed perfectly neutral. It is absolutely necessary to carry out these preliminary stages of manufacture very carefully, as traces of acids or other impurities contained in same may discolor the gelatine produced.

Washmills. There are several distinct types of construction, of which the following may be mentioned:

1. Half-round mills about 6 ft. wide, 12 ft. long and 42 ins. deep, provided with perforated false bottoms and eccentrically arranged paddles.

2. Revolving circular washmills into which water is injected by means of a hollow perforated shaft passing through the center of the mill. Both these types are mainly used for washing ossein and material of finer structure.

3. For washing calf-pates or hidestock the so-called roller washmill is generally used, which consists of a circular tank, 16 ft. in diameter and about 40 ins. high, in which revolves a cone-shaped roller.

The average speed of these washmills ranges between 14 to 20 revolutions a minute. After the raw material is thus prepared, it enters the second stage of operation, namely:

II. Dissolving. The general construction of extraction tanks is about 6 ft. in diameter and 5 ft. high, provided with false bottoms and a perforated circulation chimney placed in the center. The extraction tanks are provided with steam coils below the false bottom, and sometimes surrounding the tank.

There are also steam-jacketed tanks, which otherwise, are practically of the same construction. The raw material is rinsed from the washmills, having absorbed about three and one-half times its original weight of water. It is then conveyed to the extraction tanks, covered with warm water, steam turned on, and the thin gelatine solutions continually drawn off, as soon as they contain from 4 to 6 per cent of gelatine. There are produced from 4 to 8 subsequent "runs," the temperature of which varies with the different factories and process applied, ranging from 130–200° F. The charge of one extraction tank being about 2000 lbs. of dry raw material, containing about 60 per cent of gelatine, will result in producing from 3000–4000 gallons of thin gelatine solution. By the usual process of extraction making different consecutive "runs," these are all of different densities and the process is comparatively slow. Therefore, many manufacturers, anxious to find a process to produce the gelatine solution in a continual run, patented processes of continual extraction which the following may exemplify.

In 1903 *Cormack* obtained U. S. Patent No. 728205 for a process using centrifugal force, consisting in washing the gelatinous material.

cutting it up, and subjecting it in this divided state to the simultaneous action of condensing steam and centrifugal force, dissolving the gelatine out of the material, passing the solution from the material by gravity and centrifugal force, and thereby filtering the solution, collecting the solution and finally drawing it off.

In 1910 *Lehmann*, Paris, obtained U.S.P. No. 964980 describing the combination in a gelatine manufacturing apparatus, of a casing for the reception of liquid, means for heating the liquid, and a rotatable

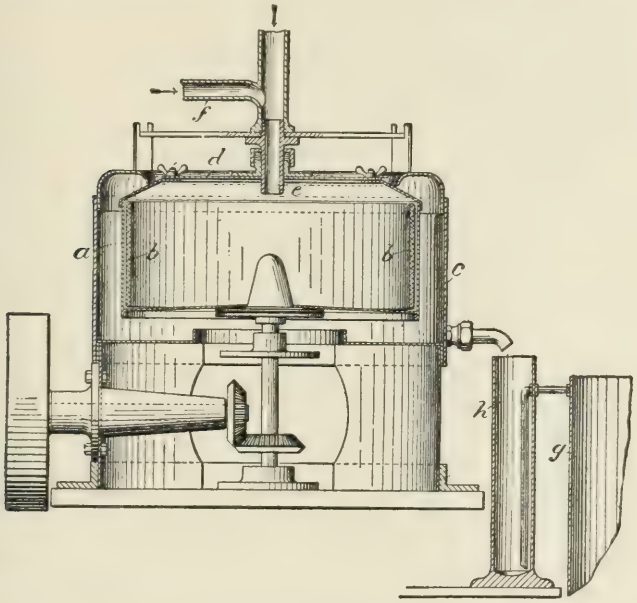


FIG. 1.—Cormack's Extraction Apparatus.

drum composed of perforated material located in said casing, means for feeding the material to be operated on into said drum, a screw in said drum consisting of a shaft and rotary curved blades mounted on the shaft for the purpose of discharging the insoluble materials from the drum, a conical outlet pipe in said casing, means for clarifying the extracted gelatinous solution comprising a filter, a rotary pump and a grease reservoir, means for desiccating the clarified solution comprising a hopper under said grease chamber, and a rotary heated drying cylinder mounted beneath said hopper, a blade in

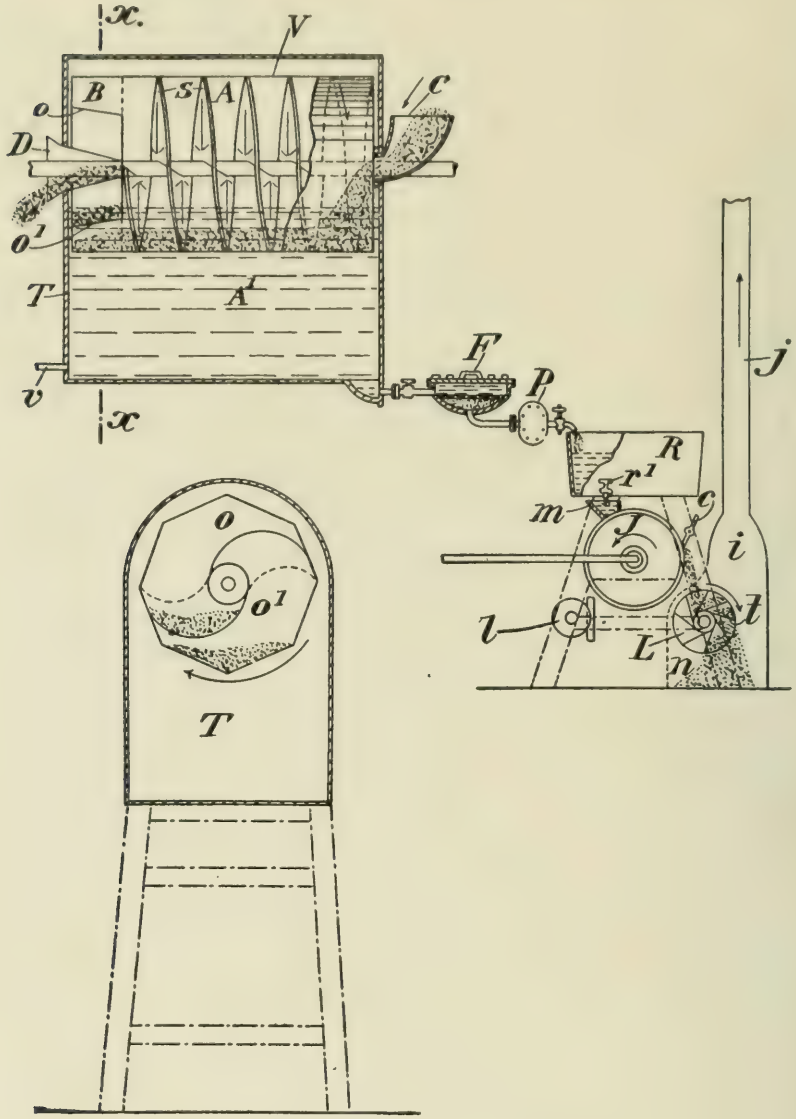


FIG. 2.—Lehmann's Extraction Process.

contact with the cylinder mounted beneath said blade, and means for hastening the cooling of the finished product.

In 1911 *Thiele* obtained U.S.P. No. 989826, an appliance for reducing animal matter to gelatine, a steam tight tank, and inner perforated cage, a steam coil between the tank and cage, a steam heater, a water pipe passing through said heater, and into the tank,

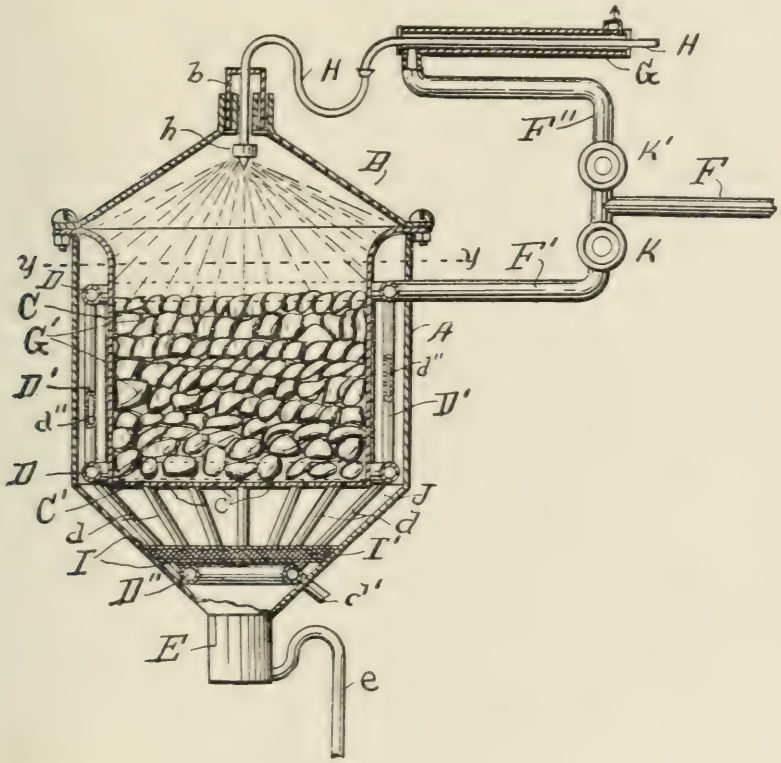


FIG. 3.—Thiele's Extraction Apparatus.

a spraying device on said pipe within the tank, a steam pipe leading to the steam coil and to the steam heater, shut-off valves in the steam pipe between the steam heater on one side and the steam coil on the other side, a settling chamber including a filtering device below the cage, a receptacle below the filtering device for receiving the filtered substance from the cage, and a siphon for drawing off the contents of the receptacle.

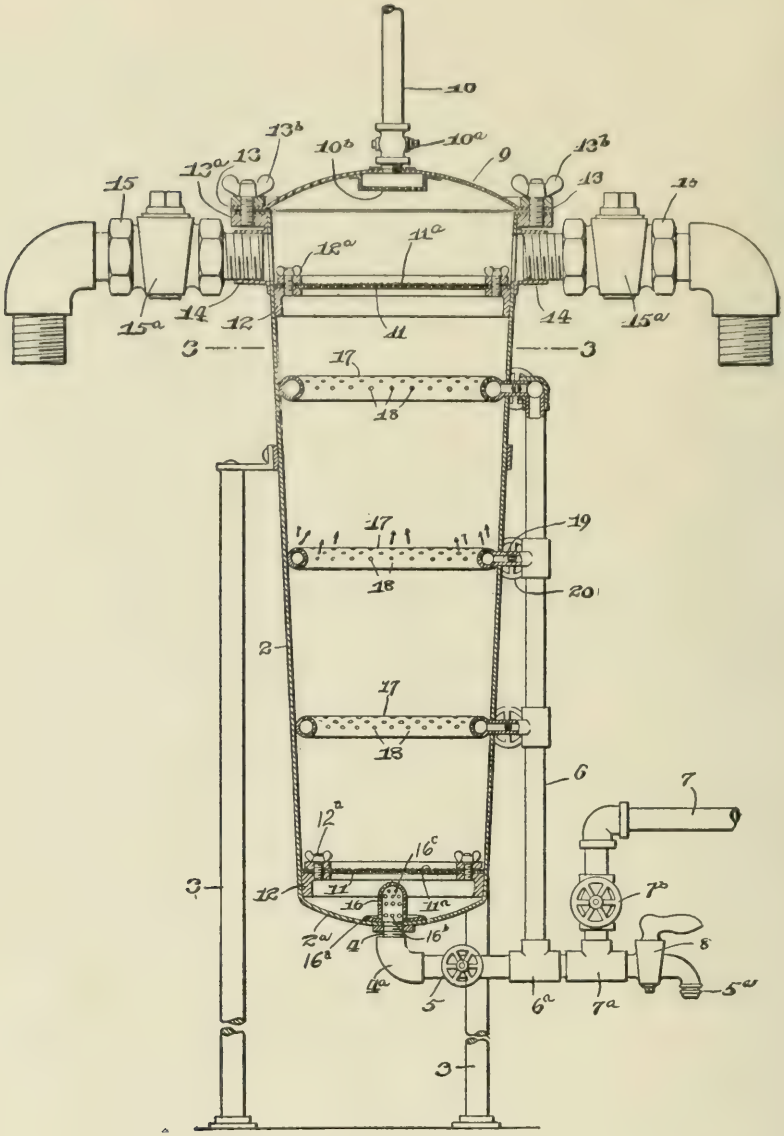


FIG. 4.—Utley's Filtering Apparatus.

This latter device arranged in pairs, enables continual operation, producing but one grade of gelatine from the entire batch. In case the production of different qualities is required, the thin gelatine liquors should be divided according to the time of efflux. Neither of the extraction processes produces gelatine liquors which are exactly clear. They should be screened into a settling tank, from which these thin gelatine solutions pass through a filtering device. Some efficient filters for gelatine are the Karl-Kiefer filter, the Union Schalen filter, or the International filter. Filtering paper or paper asbestos pulp are generally used in these constructions.

Utley, in U.S.P. No. 961180 describes a charcoal filter which besides giving a brilliant filtrate, claims to eliminate discoloration.

In some cases the last extracted portions or runs of gelatine are very cloudy and the filters before described are not in state to render the filtrate of great brilliancy. In such cases these runs should be clarified, either by the alum-phosphoric-acid, blood albumen, $= SO_2$ or egg albumen processes. The only drawback of these chemical clarifications is that the gelatine solutions are weakened, and in some other processes there remains a soapy odor, with a tendency to foam and quicker putrefaction. The clarified thin gelatine solutions are usually kept in storage tanks for 6–8 hours, giving time to settle. Usually a very slight precipitation occurs in these solutions. These purified gelatine solutions now pass into the third stage of manufacture, namely, concentration.

III. Concentration. The concentration of the thin gelatine solutions is usually made by evaporators. Concentration in open pans is probably entirely eliminated by this time. Single, double and triple effects are used as evaporators, depending on the size of the factory and the quality of gelatine to be produced. Very common systems of evaporators are those of, Yaryan, Swenson, Zaremba, Kestner.

The thin gelatine solutions are concentrated in the evaporators from 4–6 per cent to 10–20 per cent, depending on the quality of gelatine to be produced. If it is the object of the factory to produce gelatine in thin sheets, it is not advisable to concentrate the thin solutions too strong, but rather draw off the solutions at from 5–6 per cent and chill them direct. It is a difficult matter to spread these jellies containing but 4–6 per cent of dry gelatine by hand. This drawback caused many attempts, which date back as early as

1870, to construct apparatus which would eliminate spreading by hand.

Following are some patents obtained on apparatus of this nature:

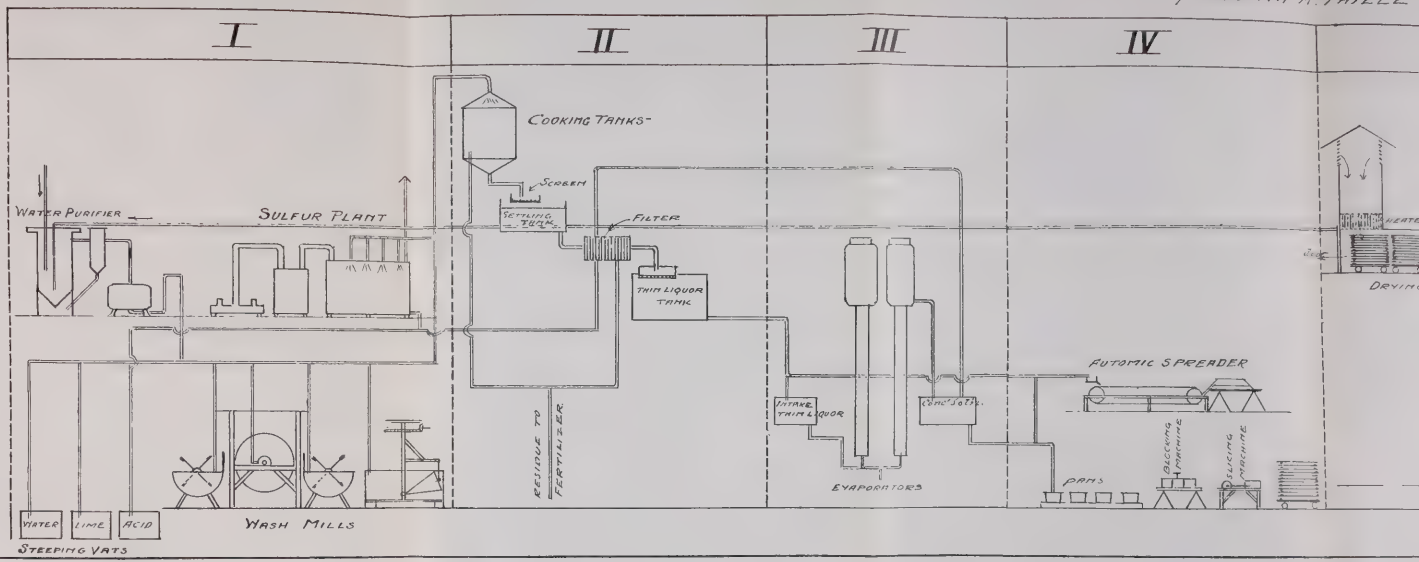
1870.	Andrew Dietz, New York	U.S.P. No. 103852
1870.	Wm. Adamson, Philadelphia	U.S.P. No. 106448
1877.	Chas. O. Garrison, New York	U.S.P. No. 185825
1878.	E. W. Leggett, Elizabethport	U.S.P. No. 205968
1886.	King Upton, Salem, Mass	U.S.P. No. 338374
1886.	Wm. P. Upham, Melrose, Mass	U.S.P. No. 343507
1888.	Chas. Keller, Springdale, Pa	U.S.P. No. 386590
1893.	F. A. Wolff, Heilbronn, Germany	U.S.P. No. 496469
1894.	Peter Cooper Hewitt, New York	U.S.P. No. 521371
1894.	Chas. W. Cooper, New York	U.S.P. No. 521947
1899.	Schill & Seilacher, Stuttgart, Germany	D.R.P. No. 119477
1907.	O. Koepff, Goeppingen, Germany	Aust. P. 33510
	Clyde Automatic Glue Spreader.	

At the present time the constructions of *Wolff*, *Hewitt*, *Schill & Seilacher*, *Koepff* and *Clyde* are in use. These mechanical spreading devices are used only where the gelatine is to be manufactured in thin slices or sheets, to be later sold in packages, or for the shredded qualities. In most cases these apparatus consist of rotary drums or endless belts upon which the solution is run, and by cooling devices chilled, scraped off, and directly laid on the nettings. By a netting is understood a frame $6' \times 3'$ upon which is stretched a cotton netting. After evaporation the material enters the fourth stage of manufacture, namely:

IV. Chilling and Spreading. If no automatic spreader is used, the thin, concentrated, evaporated gelatine solutions are drawn off into molds. The molds are usually pans 36 ins. long, 5 ins. deep, 9 ins. wide at the top and 8 ins. wide at the bottom, giving them a tapering form in order to allow the jelly to be easily turned out. These jelly blocks are then separated into smaller blocks by means of a blocking machine, which are again made into thin slices by means of a slicing machine. These slices are then laid on the nettings by automatic machines or by hand and the nettings subsequently piled one upon another, about $1\frac{1}{2}$ ins. apart for the purpose of circulation, to a height of twenty-five or thirty racks upon a car or truck, and now pass into the fifth stage of manufacture, namely:

Diagram Showing Manufacture of Gela

By Ludvig A. Thiele



Plans of Drying Kilns

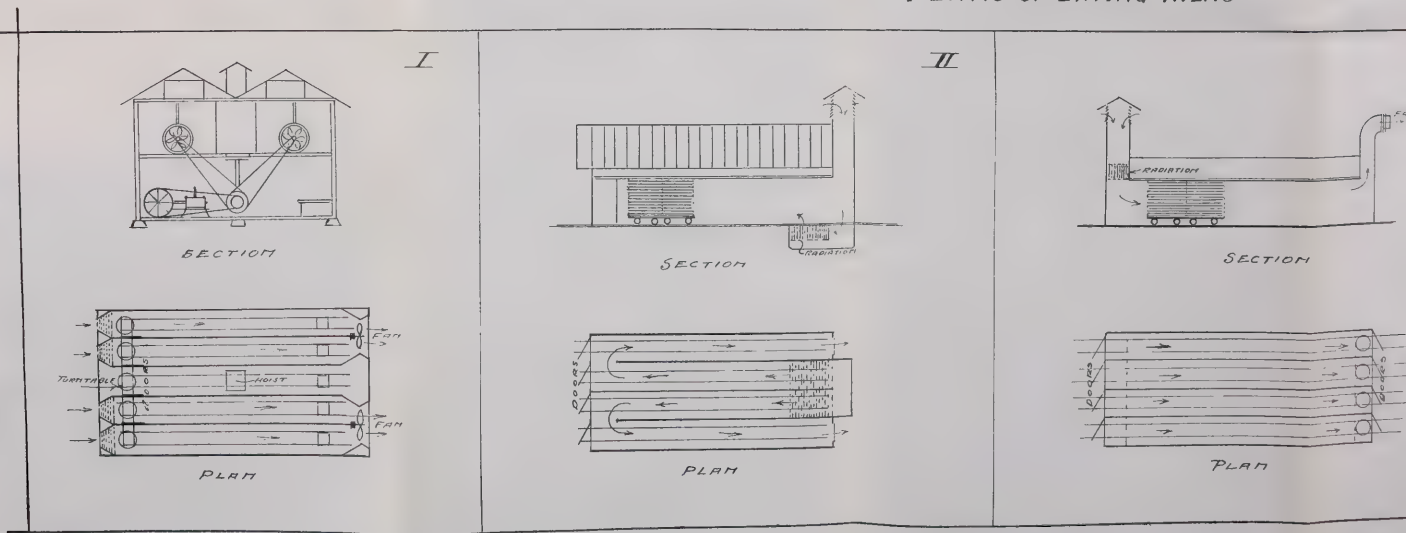
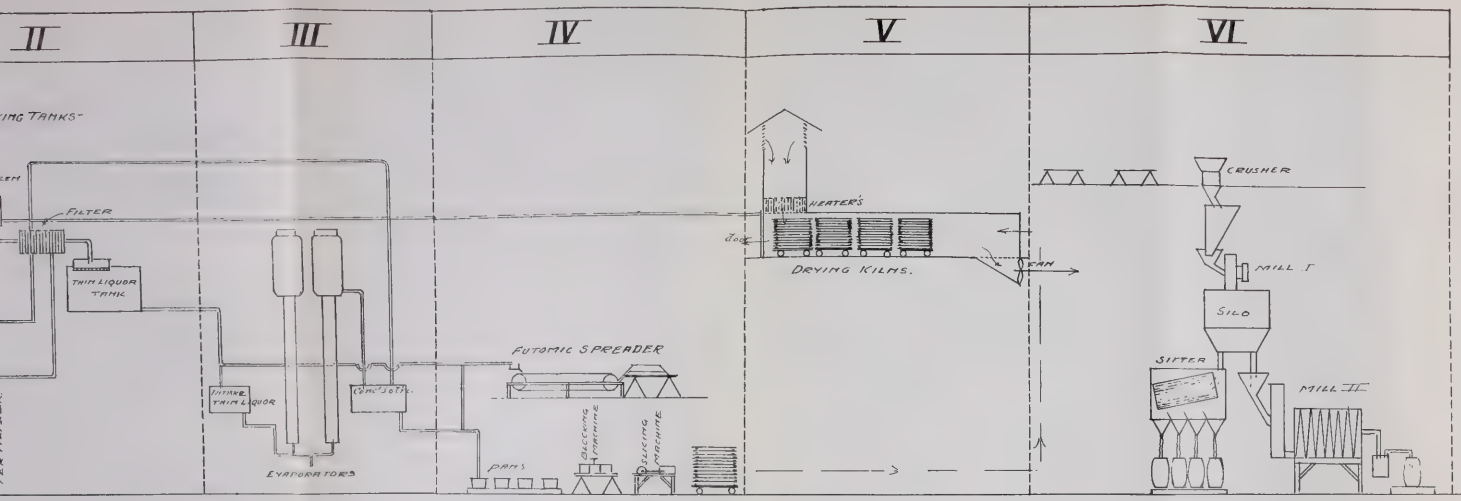


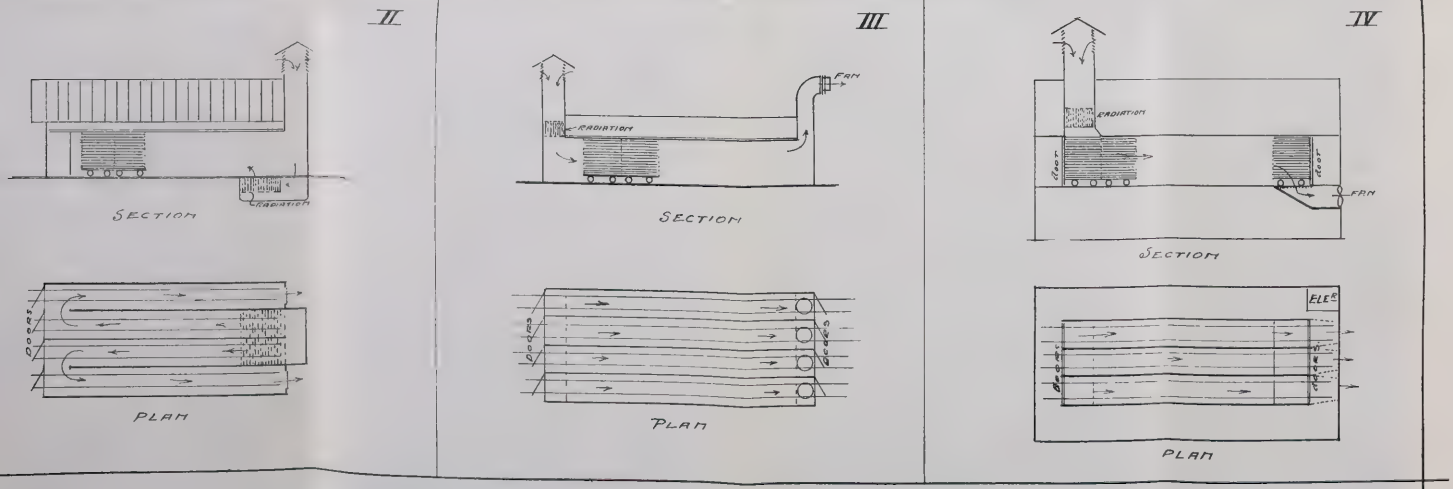
Diagram Showing Manufacture of Gelatine

By. Ludwig A. Thiele.



Plans of Drying Kilns

By Ludwig Thiele



To face page 560

V. Drying. On the accompanying folding plates are shown four distinct types of drying processes.

The drying of the gelatine is conducted in channels or kilns which are provided with rails for the better handling of the trucks. These alleys have a total length of from 70 to 100 ft. × 6 ft. 6 ins. square, are provided with heating coils at one end and exhaust fans at the other, or with blowers arranged before the heaters, a continuous current of air being blown or drawn through the channels, while the cars conveying the gelatine slices are passed in the opposite direction through the channels. The material difference between the use of blowers or exhaust fans is the difference in horse-power required to run them. The drying process is carried on at a temperature varying from 85° to 105° F. This process is a most important one, as an inefficient circulation of saturated air in the kilns will produce moldy goods, a too strong current of air will warp the sheets, a too slow current will cause the gelatine to adhere too strongly to the nettings, while too great heat will cause the gelatine to turn liquid and run through the nets, therefore, the design of the drying plant should have the most careful consideration, as the following explanation of the drying theory may illustrate.

The process of desiccation by means of heated air rests entirely upon its avidity for humidity, but the capacity for absorption varies enormously with increased temperature. At 0° F. the absorption is very low. At 152° F. considerable, while at 212° F. it is infinite.

If the air, for example, contains a certain quantity of vapor, it is said this vapor has a certain elastic force, which is expressed in inches of mercury. When air is charged with all the humidity it can carry, it is said to be saturated. The following table gives the data of the elastic force of vapor contained in saturated air at temperatures ranging from zero to 212° F.

The weight in pounds of the vapor with 100 lbs. of pure air at any given temperature and pressure is given by the formula,

$$\frac{62.3 \times E}{29.92 - E} \times \frac{29.92}{p},$$

where E equals elastic force of the vapor at the given temperature in inches of mercury; p equals absolute pressure in inches of mercury = 29.92 for ordinary atmospheric pressure.

TABLE II

Temperature.		Elastic Force of Vapor.		Weight of Vapor.		Weight of Vapor Mixed with 1 lb. of Air.
° F.	° C.	Inches. Mercury.	Mm Mercury.	Pounds per Cubic Foot.	Grams per Cubic Meter.	
0	− 17.8	0.044	0.11	0.000079	1.25	0.00092
12	− 11.1	0.074	0.18	0.000130	2.08	0.00155
22	− 5.6	0.118	0.30	0.000202	3.22	0.00245
32	± 0	0.181	0.46	0.000304	4.86	0.00379
42	+ 5.6	0.267	0.67	0.000440	7.04	0.00561
52	11.1	0.388	0.98	0.000627	10.01	0.00819
62	16.7	0.556	1.41	0.000881	14.08	0.01179
72	22.2	0.785	1.99	0.001221	19.53	0.01680
82	27.8	1.092	2.77	0.001667	26.68	0.02361
92	33.3	1.501	3.81	0.002250	36.02	0.03289
102	38.9	2.036	5.17	0.002997	47.96	0.04547
112	44.4	2.731	7.63	0.003946	63.16	0.06253
122	50.0	3.621	9.20	0.005142	82.31	0.08584
132	55.6	4.752	12.11	0.006639	106.22	0.11771
142	61.1	6.105	17.90	0.008473	235.65	0.16170
152	66.7	7.930	20.14	0.010716	171.56	0.22465
162	72.2	10.099	27.91	0.013415	214.76	0.31713
172	77.8	12.758	32.58	0.016682	266.91	0.46338
182	83.3	15.960	40.53	0.020536	328.78	0.71300
192	88.9	19.828	50.54	0.025412	402.52	1.22643
202	94.4	24.450	62.10	0.030545	488.79	2.80230
212	100	29.921	76.00	0.036820	589.49	Infinite

The above table shows that the capacity of air for water is not in proportion to the temperature, but progressive. The degree of saturation or relative humidity of the air is determined by the use of the dry and wet bulb thermometer (psychrometer) which instrument necessitates the use of hygrometric tables.

A very handy device for the determination of the humidity in air is manufactured by the Taylor Instrument Co., under the name of "Hygrodeik." In order to get the most satisfactory results in drying it is necessary to make the aforesaid observations in the ingoing and outgoing air, as well as determine the velocity of the air current by means of an anemometer.

In the process of drying there will also be observed that

(1) The more concentrated a solution the longer it will take to dry;

(2) The thinner the solution is chilled the easier the process will be accomplished.

This paradox may be explained in this way:

A slice of gelatine of 4 per cent jelly weighing about 75 gram gives a dried sheet weighing 3 grams. Therefore, from one sheet of gelatine 72 grams of water must be extricated. The first 50 parts of water will be readily taken up by the air current, but after this, the surface of the gelatine sheet has already hardened to such an extent that it is more difficult for the remaining 22 parts to escape. The more concentrated a solution, the harder the surface will become during the first part of the drying, and a much slower final process will be the result. On the other hand, the spreading of thin solutions requires very much more labor, a greater number of trucks and nettings, a larger space in the alleys, and, consequently, larger investment, as will be explained in the following example based upon a production of 2400 lbs. of gelatine daily. This production has been chosen, as manufacturing on a lower scale has proven uneconomical.

TABLE III

2400 POUNDS (1090 KG.) GELATINE TO BE PRODUCED

Requires 4000 lbs. (1818 kg.) of Raw Material at 60 Per Cent.	In Thin Sheets at 3 gr.	In Medium Sheets at 9 gr.
There will be drawn off of 4% solutions	7,200 gals. (27,270 liters)	
Of 12% concentrated solutions		2,400 gals. (9,090 liters)
Molds required	1,818	606
Gelatine slices made	363,600	121,200
Frames and nettings required	7,575	2,525
Trucks required	252	84
Water to be extracted in alleys	57,576 lbs.	17,592 lbs.
Alleys necessary (theoretical)	10	4
Alleys necessary (practical)	14	7

After passing through the drying channels the gelatine enters the last stage of manufacture, namely:

VI. Grinding and Packing. The dried gelatine sheets are taken from the nettings, thrown into a crusher, running at 250 revolutions a minute, and requiring about 2 H.P. The crushed gelatine, so called "flake" passes into a silo, thence into a mill of the dismembrator or disaggregator type, is screened to different granulations, and barreled up in the different forms as required. For

still finer powdered goods it is necessary that the gelatine pass through another mill which will reduce all the crushed or granulated gelatine to powdered form, from 50 mesh upward, according to requirements.

Proportion of power to production (according to conditions)

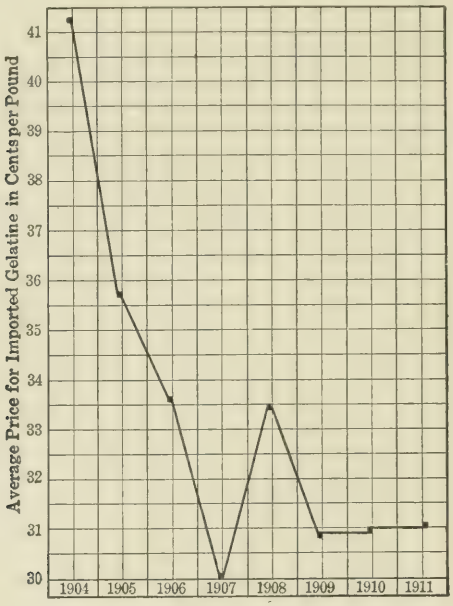
= 1 H.P.:12–20 lbs. gelatine.

Capital required per production of 1 lb. gelatine

= 31 cents–25 cents.

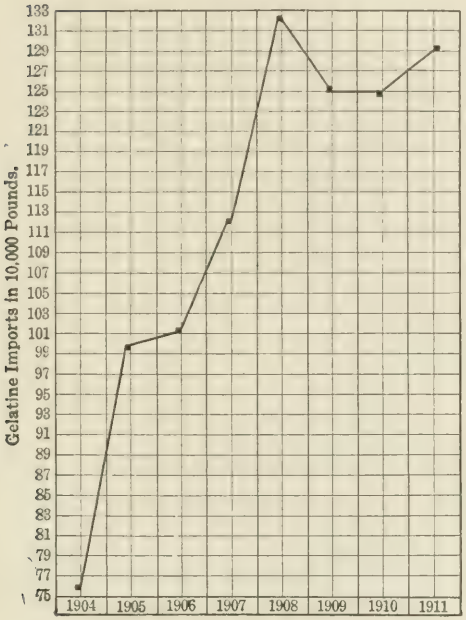
Consumption = 55 gr. per capita, U.S.A.

TABLE IV



In Table IV are shown the *imports of gelatine* into the United States during the past eight years, while Table V shows the *fluctuations in price* during the same period.

TABLE V


Gelatine Imports in 10,000 Pounds.
133
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1911

THE ADAPTATION OF THE CENTRIFUGAL PUMP TO CHEMICAL PROBLEMS

By F. G. WHEELER

Read at the Washington Meeting, Dec. 22, 1911

It has always seemed to me that the machine which is most used in chemical engineering is that one which is used to move liquids from one place to another, either from one tank to another or to circulate it through various devices for the purposes best known to the user. It makes no difference whether the engineer wants to raise water from a mine, or to discharge a sludge to a stream, the pump in some form is the most useful agent which can be applied. In all problems of this kind, that kind of a pump which has no valves and which depends alone upon centrifugal force to impart energy to the liquid has appealed to me as the best device which can be selected. As it has been manufactured the last few years, it moves the liquid with less loss of energy than any other device, and stands more abuse and can be operated with cheaper labor than any other machine for this purpose. In the handling of water in quantities above 100 gallons per minute, it is replacing all kinds of steam pumps, except perhaps the very large fly wheel engines. It can be used to pump solutions whether they are acid or alkaline, clear or muddy, viscous or mobile. In the use of the centrifugal pump for this chemical service, however, we must have a machine which is adapted for the heaviest kind of work. It must be built for severe duty from the day that it is put into commission to the day that it is thrown on the scrap heap.

In selecting a pump for service of this kind, we must consider first whether it will meet the condition as well as any other device which we could use. I have found that in quantities above 100 gallons per minute the centrifugal will handle any liquid which will flow, or can be made to flow readily. The second point to be considered is the first cost. In many instances the first cost of a machine

will determine whether it can be applied. Because the centrifugal pump appeared simple, many manufacturers tried to meet all conditions with it, using the cheapest kind of a machine to compete with the steam pump, but it has been shown that it is as expensive to install a good centrifugal pump at the present time as it is to install a steam pump, but the pump must be thoroughly well built in order to compete on the basis of efficiency.

Historically, the pump has been known since the eighteenth century, but the first designs were more like fans than pumps, and were both crude and inefficient. Up to the time when the water turbine was developed the laws which governed the working of a

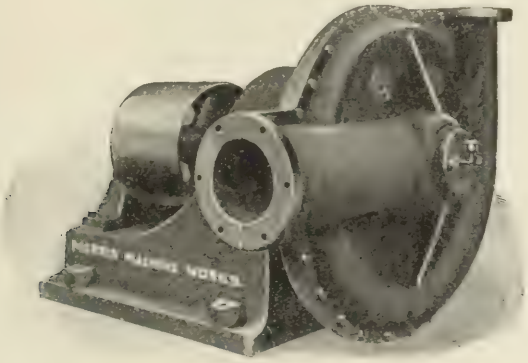

FIG. 1.—Type of Pump Used by Many Mills To-day: Double Suction, Vertically Split Shell.

centrifugal pump were but meagerly known, and we have many pumps in operation to-day which were designed before the turbine was developed or were copied from those designs. When the laws which govern the operation of the reaction turbine were studied, it was learned that the centrifugal pump was in a general way a turbine run backward, and from this there were designed various makes of centrifugal pumps which operated much better than the old type. There were many difficulties still to be overcome, and it has been but a few years since we have had a really efficient, commercial machine, which competes with other devices because of real merit.

We are all familiar with the cheap centrifugal pump which is used by contractors and many factories at the present time. I have seen them used in excavations, in quarries, in paper mills; and

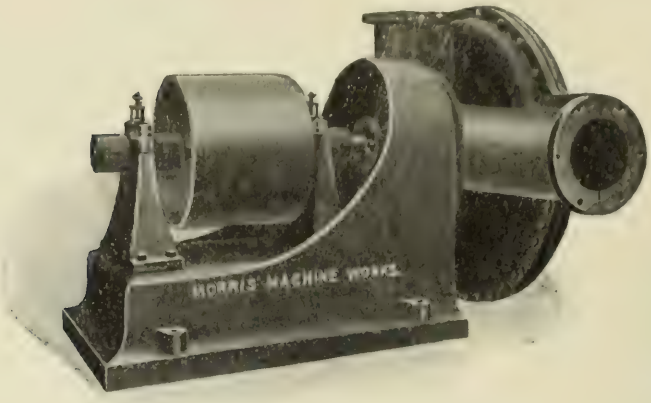

FIG. 2.—Showing the Overhung Casing.

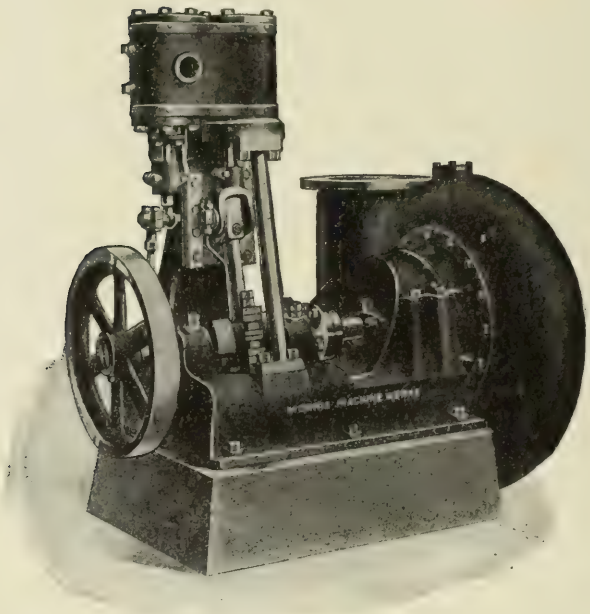

FIG. 3.—This Pump Shows the Solid Volute and the Shell so made that the Discharge can be Set in any Direction, Single Suction.

in many other places. They have a two-piece shell, overhung from the support at one side. They are split vertically, and have a single suction on the side opposite from the support. An open fanlike impeller does the work, and enters the casing from the side of the support, through a gland which acts like a bearing. It is claimed that this overhung casing has the advantage that the discharge can be turned in any direction. We shall all have to admit that it does

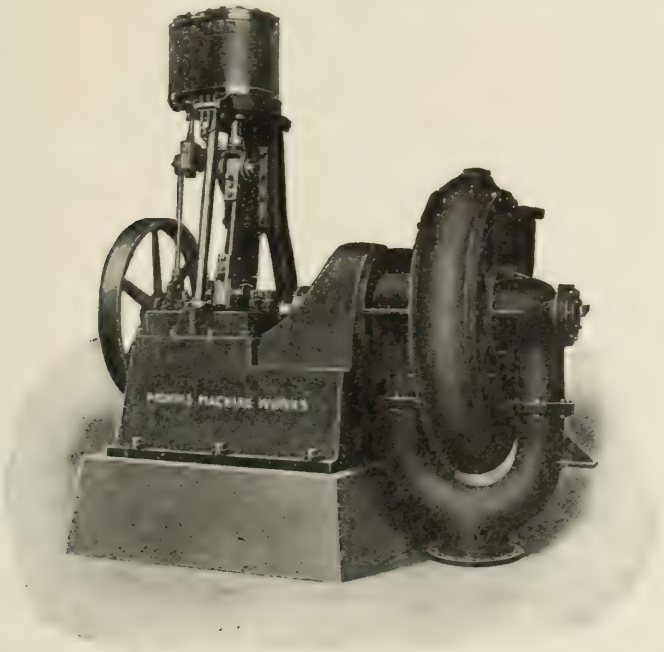

FIG. 4.—Pump Showing Double Suction Solid Volute Overhung Casing.

have this advantage, which is really that of saving one ell. Its disadvantages are many. There is one modification of this which has a solid scroll and two side pieces, but the principle is the same. The single inlet causes an axial thrust toward the suction, and the first alteration in design was to make the machine with a double suction. This made the casing still further from the support, and to overcome the long overhang, there was placed on the outer end of the shaft another gland. This I presume was to be used as a bear

ing to help support the shaft, but in pumps which I have examined, the gland only wore out the outer end of the shaft, either from the vibration of the casing, or the strain of the impeller. This overhung

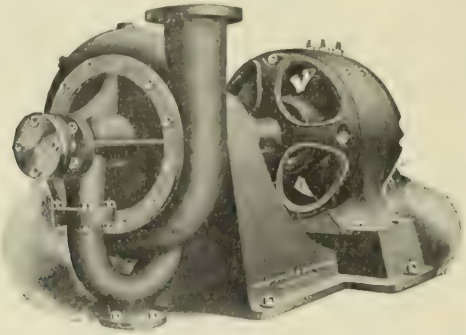

FIG. 5.—Another View of a Pump as Shown in FIG. 4, Showing an Outside Gland Acting Like a Bearing.

casing, in the case of some sand pumps was changed to one having a central support. This was considered severe service and it was thought the better method because it decreased the gland wear, and helped to keep the shaft in alignment. This central support

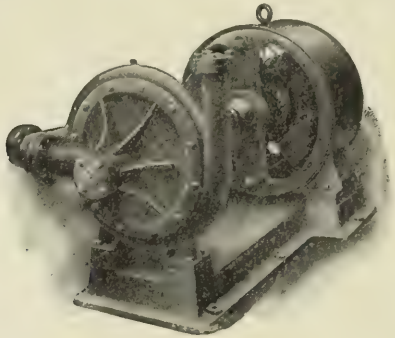

FIG. 6.—Similar Type to Fig. 5, but with Central Volute Support.

has been almost universally adopted at the present time, but for many years, the manufacturers retained the overhung casing as being of advantage in changing the direction of the discharge, and a much cheaper construction. Some of these casings are still used, even with

more modern pumps. One maker used the suction pipes to support the casing, but I have only seen those of this one manufacturer supported in this way. All of the pumps so far described, are inefficient, inaccessible, and crude, because they have a minimum amount of machine work to make them fit; they are rough castings, thin, and poorly designed. If used for anything but the handling of water they quickly give out requiring repairs or new castings. The wear on the shaft in the glands, where these were used as a bearing, caused the builders to put in outboard bearings, which were supported directly from the concrete foundation. Many, however, even at the present time use the glands as bearings, and the shafts are lubricated in these glands with grease or oil.

The next improvement of any importance came about when the laws were studied more closely, and the open fan-like impeller was shrouded, and finally supplanted by what is known as the enclosed or shrouded impeller. There were many modifications made by different manufacturers, such as the single suction, the double suction, and the double single suction where the dividing vane came to the periphery. All worked upon the same principle, that that which entered at the hub, must be discharged at the rim. This put more energy into the water, and not so much into friction. Between the sides of the impeller and the wall of the casing, the water revolves only half as fast as it does with the open impeller, because with the open impeller the clearance between the vanes and the sides must be a minimum, and the water must brush the sides as fast as the impeller revolves, whereas the closed impeller has greater clearance and the speed of the water divides itself between the revolving disc and the sides. This increases the efficiency, and also decreases the wear on the casing. It makes an efficient machine which can be built more easily than an efficient open impeller pump because the clearance need be only at one location. In an efficient open impeller pump the casing and the sides of the vanes must be accurately machined to fit. With all of the open impeller pumps which I have examined, however, the casing and the vanes were only as smooth as the castings as they came from the mould, and no attempt has been made to make the clearance particularly small. I have seen a clearance of over $\frac{1}{4}$ in., and the pump had an efficiency of 20 per cent. I have seen a 6-in. pump in a paper mill, lifting about 1000 gallons per minute to a height of about 30 ft. which requires about $7\frac{1}{2}$ horsepower, being driven by an 8-in. double-ply belt, which was so severely

treated that the complaint concerning the pump was that they didn't seem to be able to keep belts on it. The speed of the belt was about 3000 feet per minute, and it should have easily been able to do 30 horse-power of work. The only way in which a centrifugal pump with an open impeller can be made to work satisfactorily is to put on a large motor or engine.

The next improvement which was of noteworthy importance was the splitting of the shell horizontally. Many manufacturers at the present time do not do this, but it lends an accessibility to the pump which is of advantage. With the shell split in this manner the entire inside of the pump can be opened in a few minutes either to clean out or to renew, without disturbing the piping or the motor. It makes the use of renewable running rings which are very convenient with enclosed impeller pumps, very simple. Two men can open a horizontally split pump of moderate size, either clean it out or renew the rings, and have it together again in about one hour. I have seen two men work six hours to open a pump which had to be taken out endwise, and put it together again. Of course, we are told that the pump is so well made that it doesn't have to be opened very often, but it is not foreseen whether the user will get some chip, or nut or bolt into it. This often happens from new piping or where some repair is being made to an intake. Several of the manufacturers who once made the solid shell pump, are changing to the horizontally split.

There are various difficulties which occur in the operation of centrifugals, and the manufacturers have been working to overcome them. The first trouble of any importance after the centrifugal was designed according to scientific principles was end thrust. This was overcome hydraulically by different methods, but there is almost always some unbalanced thrust which will cause trouble if it is not taken care of by mechanical means. The next thing in importance is the low efficiency. Every effort in both design and construction has been given to create pumps which will deliver the highest possible amount of energy compared to that put in. Large strides have been made, and new ideas are described with large claims for them. There has also been the simplification of the parts, so that pumps can be built as cheaply as possible. Before taking these up more in detail, I shall recall a few of the principles which govern the design of the centrifugal.

In the first place, I would like to point out that there have been

worked out formulæ for almost every part of every kind of pump. As with the design of the water turbine, the design of the water passages, the shape of the vanes, the peripheral speed of the impeller have to be fixed for a definite amount of liquid against a definite head. If this amount of water is changed in any way whatever, the efficiency will drop, and the alteration of the head will also change all of the dimensions. For this reason many manufacturers work out from operating pumps a set of charts which they follow, and the result is that the pump which they might deliver is not perhaps according to the best theories which have been formulated, but the pump will meet conditions which the other pump will not. Even at the present time, if one wants a very flexible pump in regard to capacity and head, the manufacturers will not guarantee efficiencies very closely. One may work out on the drafting table the exact shape of the water channel, for instance, and any slight error made in the pattern shop, in the foundry or in the machine shop will alter the fine point which is desired so much that it will be completely lost. After the little alteration is made, and even worked up to the finished pump, a slight change, such as the pressure of the gland on the packing will more than offset the advantage gained. For this reason, we may aim more to accomplish what is wanted in the adaptability of the pump rather than to gain a small increase in efficiency.

The size of the pump is determined by the amount of liquid and the speed at which it is to be discharged. Usually a speed of 10 to 12 feet per second is used. It is then simple to find the pipe diameter. Secondly, we have to determine the head against which the pump is to discharge. This total head is made up of several different parts. It is generally considered to be made up of the pressure, suction, friction, velocity and orifice heads. If the inlet and outlet of the pump are the same, the orifice and velocity heads are measured as the suction head. The total head then becomes the sum of the pressure, suction and friction heads. To better understand how to adapt a pump to any total head, let us consider what speed must be used to force water up into a very high standpipe. If the water has reached a standstill and there is none being discharged, the speed of the impeller must be such as to hold the water against that pressure. It can be compared to a falling body, and the velocity of the periphery of the impeller will be the same as that of a falling body, falling from that height in a vacuum. We can easily calculate that speed from

the law of falling bodies, $V=\sqrt{2gh}$. For the pressure which the pump can maintain with no discharge this law will be exact, but when the pump delivers water, there are a large number of other factors to be considered. The first factor is the angle between the vane in the impeller and the tangent at the rim. In a general way the larger the angle, the less the pressure will drop with an increased delivery and constant speed. The smaller the angle, the more quickly will the pressure drop with an increase in the amount discharged. As the water is drawn away from the pump by opening a valve the pressure will either change or remain the same. If the angle mentioned above is small, the pressure will drop. If it is about 30 degrees, it will be almost constant; if it is 45 degrees, it will rise slightly at first and then drop with increased delivery and if it is radial or greater than 90 degrees, it will rise almost its entire length. For ordinary work, the different manufacturers have a set of curves which shows exactly what each form of impeller will do. These are obtained from testing every pump which they make, and tabulating the results accordingly. For the working pressure the formula then becomes $V=n\sqrt{2gh}$ where n is dependent upon the angle between the vane and the tangent to the circle. The amount discharged will also depend upon the width of the slot. If we draw a parallelogram with the base equal to the peripheral velocity, the angle between the base and the side that of the tangent of the vane and the tangent of the circle, the altitude equal to the velocity of the water from the impeller, then the diagonal drawn from the angle of discharge will be equal to the velocity head of the water under those conditions. Theoretically the cross-sectional area of the slot at the rim should be the same as the suction opening at the hub, but many manufacturers make it 85 per cent of that area, increasing the speed of the water slightly as it passes through the impeller. From this for a given discharge rate of flow it is seen that the width of the slot depends upon the diameter of the impeller, which in turn depends upon the speed at the periphery and the working head.

Many different kinds of motive powers are used and to meet the speeds of these, the pump has to be designed with different impeller diameters so that the proper peripheral speed may be obtained according to the head and vane of the impeller. Since the angle of the vane controls the value of n in the formula $V=n\sqrt{2gh}$ many designers keep that angle the same at all diameters, so that they may change the diameter of an impeller by simply turning it down on a

lathe. A spiral having that property is a logarithmic spiral having the equation $\log \rho = a\theta$ or $\rho = a\varepsilon^{b\theta}$. It will also be noticed from the law of falling bodies that the head varies as the square of the speed. In other words, if we want to double the head we multiply the speed by 1.414. Also, if we increase the speed at the rim, we increase the speed of the water through the impeller, so that the pump will discharge a much larger quantity of water. The increased amount of water which the pump will throw will depend upon the size of the suction opening and the internal friction of the impeller itself. This can be closely determined by using a constant for the impeller. This constant is equal to the quantity at any given speed, divided by the square root of the head. If then, we determine n in the formula $V = n\sqrt{2gh}$, where n is the ratio between the working head and the shut off head, and then apply the above formula $K = \frac{Q}{\sqrt{h}}$ we can easily determine the quantity which the pump will discharge at the higher speed.

It has been shown that at a given peripheral velocity a small impeller run fast is more economical than a large one run slowly for the smaller impeller has much less surface and although the power increases with the speed, it increases more rapidly with the larger surface. In the installation of the centrifugal pump, the quantity and the head for which the pump is designed should be adhered to as closely as possible. There will be a narrow range in which the efficiency of the pump will be the highest. Every effort is made to make that range as wide as possible, for under everyday working conditions, we cannot expect the pump which will pump only one quantity against one head to be satisfactory, and the larger the range under which a pump can be used, the better it will be commercially. Some of these difficulties can be overcome by the use of some kinds of motors but they will be considered later.

As stated before one of the practical problems in the design of a centrifugal pump is taking care of the end thrust. There have been various ways of balancing this hydraulically, but the more important ones are those which were devised by Jaeger and by the Sulzer Bros. in Germany. With single stage pumps, the one devised by Jaeger is used where the pump has an enclosed impeller and but one suction. The idea consists in placing a running ring on the side of the impeller opposite the suction and connecting the chamber so made with the interior of the impeller by suitably placed holes.

This and other devices to overcome the end thrust of single suction pumps are very satisfactory as long as the pump does not wear beyond the point of adjustment. In double suction pumps the pressure is hydraulically equal. It is better, however, to place a small collar where it can take up inequalities. There are many little things within a centrifugal pump which might cause thrust, and some of these are utilized by different manufacturers to balance the axial pressures, but the amount of thrust will change with wear and there are usually troubles from this source. Besides the single suction feature, thrusts will be caused by ribs inside the casing. If there is need for repair or a brace inside the casing, the rib or lug will cause an unequal flow on one side of an impeller, and thrust will result. Another cause is that in the casting of an impeller, the core is usually made in two pieces and if these are not placed properly the vane will have a diagonal slant and this will cause unequal discharge from the rim. Also there will be an oblique discharge from an impeller the one side of which is smaller than the other side, or if an impeller has a piece knocked out of one side, it must be filled in very accurately and carefully, so that there is neither a lug on the side of the impeller, nor an open place in the rim. The best way to remedy this difficulty is to put a ring entirely around the circle, with the piece to fill the opening attached to it. A large number of manufacturers consider it an advantage which increases the efficiency of a pump to use diffusion vanes. If diffusion vanes placed in the casing are not exactly in line with the slot in the impeller there will be a thrust so that if in operating a pump having diffusion vanes, after it has been assembled the bearings begin to run hot it might be from this cause. There is another way of balancing a single suction impeller, and that is by using a disc attached to the shaft and so located that the pressure of the discharge is on one side, and either atmospheric or suction pressure on the opposite side. The criticism of this type is that the wearing joint will increase the leakage, and the thrust will not then be balanced.

To increase the efficiency, I have mentioned the enclosed impeller. The angle of the vane will influence the efficiency for the reason that it will increase or decrease the internal friction by changing the length and cross-section of the channel. Also, the smaller the angle the lower is the working pressure at the same peripheral speed. This necessitates running an impeller with the small angle much faster than one with the larger to obtain the same working head. This

creates more friction and a lower efficiency. Since the angle of the vane is determined by the characteristic desired, this loss of efficiency must be balanced against the advantages of the particular characteristic needed. One of the chief losses in the pump with the enclosed impeller, which is the only one which will be considered is the back leakage from the discharge chamber to the suction chamber. This will amount ordinarily to about 5 per cent. Different devices have been used to make this a minimum. Some are simply closely fitting rings, while others are labyrinth packings. The use of a labyrinth, however, necessitates clear water with no grit. Another loss is from eddy currents within the casing. This has led to the use of the diffusion vanes. These are vanes shaped in the casing to gradually direct the water from the rim of the impeller to the discharge of the pump. They are used to prevent shock losses. There is a discussion now between the different manufacturers as to the advantage of these vanes, each one claiming the other to be in the wrong. There is only one point which is really interesting, and that is that the one who does not use diffusion vanes competes upon an equal efficiency basis with the one who does. To reduce eddy currents one manufacturer divides the casing opposite a radial discharge with a vane so arranged that the water must take the shorter route to the discharge opening. This pump seems to show about the same efficiencies as the others. There has been introduced recently a pump in which the diffusion vanes are fixed in a ring which can turn free from the hub of the impeller. The shape of the vanes in this ring is of course different from those in the stationary vane, and it is claimed that this revolving vane increases the efficiency 25 per cent.

There is always the aim to use a more simple design to decrease the price. When a manufacturer has to meet competition, he will frequently offer a pump which is simpler, and for which the same efficiency is guaranteed. It will be seen on close examination that there is a lack of one of the chief features desired. It will be either accessibility, ruggedness of design, or some such point. The pump will have but one bearing, and will depend either upon a gland for a bearing or upon a rigid coupling to the motor shaft, and use the motor bearings. Another scheme is to have the armature of the motor and the impeller of the pump on the same shaft. One manufacturer has brought out a line of both horizontally and vertically split pumps, so that they can be assembled in single or multiple stages to suit the condition. The use of the vertical split shell seems to me to

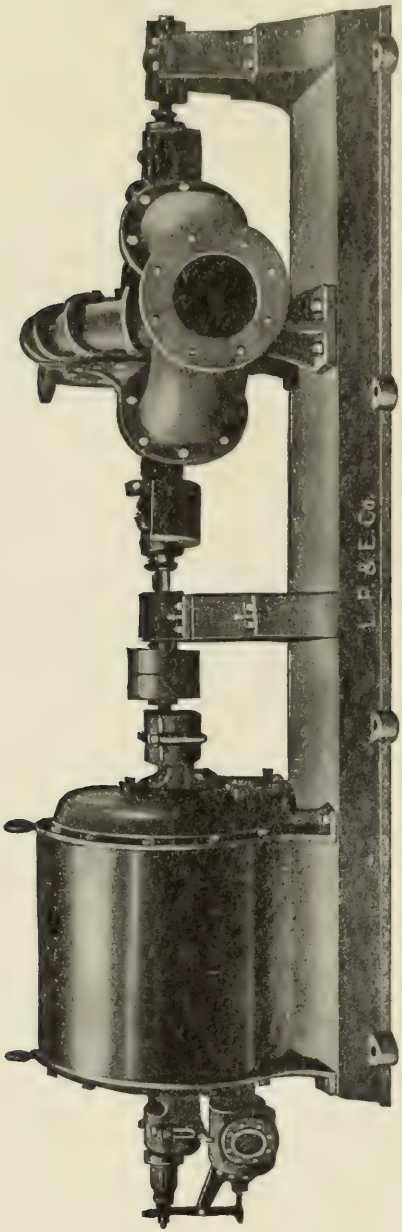

FIG. 7.—A Solid Shell Pump with Pedestal Bearings, Well Supported but Inaccessible.

be a poor design for the reason that just where one needs wearing qualities, there is a joint and packing. Also, the distance at the running joint depends somewhat on the packing. With the single piece volute or with the horizontally split shell the running joint is always fixed when the rings are made, and the distance between them is a minimum. I might state here that in replacing a sheet packing at any time in a pump, the new packing should be exactly the same thickness as the original packing, because in machining the case, the work is usually done with the packing in the joint, and in order to have the casing the correct shape, the thickness of the packing must be the same.

When purchasing a pump from the dealers, the details should be most carefully examined. There has always been an impression created by the first forms of the centrifugal, that this type of pump must be necessarily cheap. For this reason there are many pumps offered to-day which are built entirely on the old lines. These

pumps cost about one-third of what a good centrifugal costs, and although the efficiency might be quite high at the start, it soon drops. I have tested new open impeller pumps, which had an efficiency of 18 per cent. These pumps are offered in competition with the better grade, and the efficiency is stated as high or even higher. Some have put enclosed impellers in old casings and so forth. I know of an instance where a firm made inquiry for a pump to handle 5000 gallons per minute against 50 foot head. One of the firms who had been building pumps of the old type, had advertised very widely a pump which they had just designed and it was thought advisable to give them a chance, more particularly since the size of the pump advertised, was the size needed. They had mentioned that this pump had an efficiency of 70 per cent, and other features which have been shown to be of advantage. When the proposal was received, it was the same old design, with the open impeller, the glands for bearings and so forth, which they guaranteed to have an efficiency of 70 per cent. They were asked why they had gone to the trouble of designing and advertising the other pump when the old style was guaranteed at the same efficiency. No answer was ever received. Many of the dealers in the old line advertise the same as the more modern manufacturers and when a purchaser sees that the machine is not up to the guarantee, they offer every possible excuse. I have seen these pumps fail when tried on the work for which they were intended. The pump dealer said that it was the turbine, and the turbine dealer said it was the pump. I have seen them use motors out of all proportion to the efficiency guaranteed. Recently in one of the most modern plants in Detroit, I saw one of these pumps with a 40 horse-power motor doing 14 horse-power work, and the motor was running so hot that the hands could not be held on the frame. The pump was guaranteed higher than even the most modern pumps can reach, but the motor pulled the load and the outfit was thought satisfactory. I might say at this time that the longer an enclosed impeller pump is operated the smoother it becomes, and the higher is the efficiency, provided that the running rings are not unduly worn. These can be replaced at very slight cost at any time, and the efficiency will be higher than when the pump was new.

In using one of these pumps for chemical problems, there are many things to consider besides the efficiency, yet this should be kept as high as possible. The pump must meet the condition, and

when the chemical engineer has to pump liquids of different densities from different tanks, at different levels through suction lines of different lengths to tanks similarly situated, the head is by no means constant, the gallonage varies through wide limits, the power required varies sometimes 300 per cent, and the dealer says it cannot be done. Other manufacturers think they can meet the problem, but it is too wide and varied for them to understand, and the pump frequently fails. A pump was purchased by the writer to meet a certain condition where a heavy viscous liquid full of sediment was to be moved from one tank to another, and a firm agreed to build a special pump at twice the regular price of one made to pump water. It came and was installed under protest because many parts seemed too light,

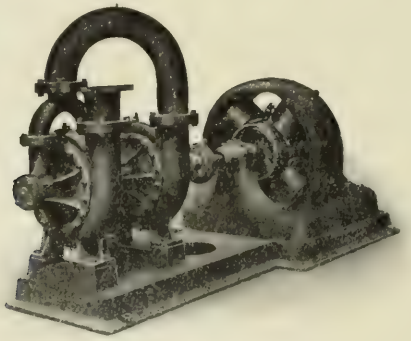

FIG. 8.—Two Pumps Similar to Those Shown in Fig. 6 Connected in Series for High Pressure Work.

the slot seemed too narrow and so forth. The builder said to install, and if it did not meet the condition they would repair. The pump lasted three weeks. The glands were torn out, the sleeves on the shaft were scored and cracked, the liquid had wormed its way into the joint between the impeller and the shaft causing the runner to wobble. This was torn beyond repair, and the running rings were useless. The firm rebuilt the pump, and it is now pumping water. We designed and built our own pump after that trial. In the design of that pump, we eliminated everything which we could and built a very heavy design, throughout.

In a pump for chemical use where the upkeep is considerable it seems to me that simplicity should be the first consideration. Although small clearances might increase the efficiency slightly, they

should be avoided except in the running rings and these should be made easily replaceable. Avoid a labyrinth packing, because it has too close clearances, and will wear excessively. Use single stage pumps, using two rather than one double stage. In this way the use of diffusion vanes are avoided, and narrow passages except in the impeller are not needed. At the exit of the impeller, do not make a narrow running joint, but leave it more like a box. The efficiency may not be as high, but you can then alter the size of the impeller at will, and there are only smooth surfaces within the casing. Secondly the chemist's pump must be easily accessible. For this reason, we built a horizontally split machine. These are made by several manufacturers, and are very easily opened to clean out a choked impeller, or to renew running rings. Another change which

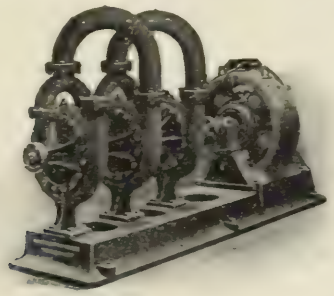

FIG. 9.—Three Pumps in Series.

we made on the pump was the separation of the suction opening from the volute. On most of the pumps of this type, unless they are extremely large the entire volute and suction connections are made in two pieces, but for accessibility and renewals, we separated the casing into seven pieces, the upper half, and the lower half of the volute, two pieces divided horizontally on each side, and the two suction inlets were joined by a Y pipe. The running rings should be as plain as possible, because all edges will wear. If a passage with an angle in it can be used it will be well to put one in, but each part should be made so that it is replaceable. In all cases I would recommend outboard bearings. These may rise from the base or be located on cantilever supports from the side of the casing. This arrangement prevents weight and wear coming on the glands, and they can be oiled or adjusted at any time. They should be much

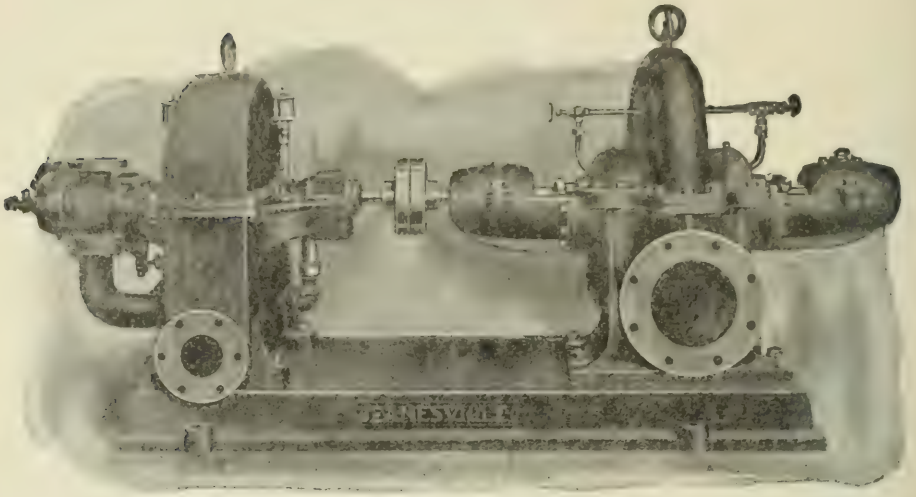

FIG. 10.—Double Suction, Horizontally Split, Central Support, Outboard Bearings.

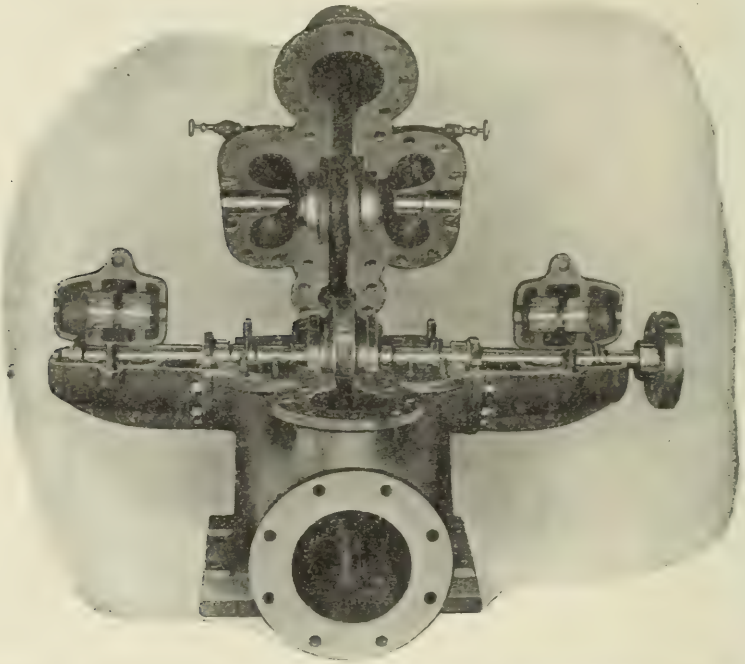

FIG. 11.—Same as Fig. 10. Open Casing Showing Enclosed Impeller, and Running Rings.

heavier than for water and if precipitates are to be handled, I would use heavy thrust collars. This is for the reason, that a chunk of material may get into one side of the impeller and not one in the corresponding side before the first one is worn down and forced through by the liquid. The result is end thrust which has to be taken up

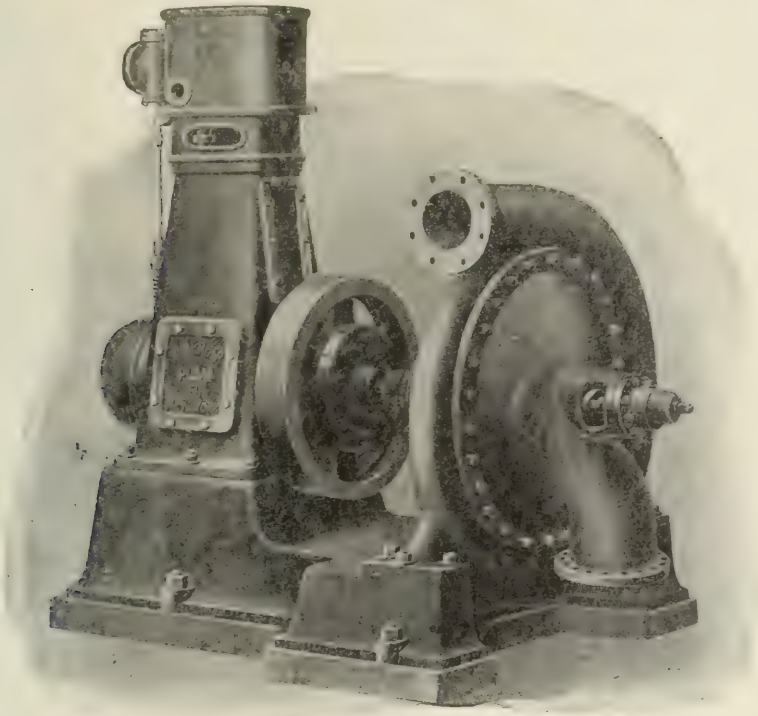

FIG. 12.—A Modern Single Suction Pump, with Outboard Bearings with the Impeller Removable from the End.

mechanically and if it is not cared for by a thrust collar where it can be oiled and adjusted, it will either force the shaft over against the motor, or push the impeller over to the side of the casing. I do not think that a marine thrust bearing is necessary but a thrust collar will not be useless. Frequently, rivet heads, bolts or trash will get into the chemist's pump from open tanks and these will disturb the hydraulic balance of the pump. In pumping precipi-

tates, to insert a screen in the suction pipe increases the suction head on the pump, and sometimes will plug with the precipitate which is being handled. Before inserting such a screen, the local conditions should be very carefully considered.

The pump for chemical purposes should be built very heavy and rugged. The casing should be made very thick. As a general rule, it seems to me to be much better to build the casing very heavy than to use a thin casing and line it. In pumping alkalis and some acids, the casing can be of the same material as the liner, and the outside skin of the casting will stand more than most materials of which a liner can be made. There is good reason, that of electrolysis, why a lining of a different material should not be used in a chemist's pump. This will be emphasized later. This also applies to sleeves on shafts. It is better it seems to me to replace a shaft, if it is of not too expensive a material than to use a sleeve. There is always corrosion at the glands, and where there might be electrolysis a sleeve does more harm than good. With the heavy casing, should be used heavy flanges. These will stand any pressure which might be put on them from outside. If a pump plugs with a precipitate, the easiest way to clean it out is to put high pressure water on the pump and push the plug out or dissolve it. The heavy casing and flanges will not give trouble under these conditions. I have seen thin pumps break when this was being done. They will also stand much more water hammer, which sometimes occurs when a pump is pushing the water to the top of a tower or standpipe and is suddenly stopped. I have mentioned the shaft and glands. These should be built heavier than for water and it is better to so shape the casing at the side so that it protrudes inwardly to the impeller, because this method keeps the liquid or precipitate from the shaft. No sleeve need be used with this construction, and the casing takes the wear. I have seen these inwardly projecting pieces chew down over one-fourth of an inch in eighteen months. We simply machined them back a short distance, and kept them in service. Another point about the gland piece itself, is the fact that when there is a liquid pressure on the gland, there might be a slight leakage from the joint where the shaft enters it. It is well to make the gland thick, and put a channel in the outside of the gland piece so that there will be no spray radially from that point. If there is, it will be caught in this channel and guided from there to suitable receivers. The impeller will wear away faster than any other part. This is due to various

causes, and the only way which will really give the best service, is to build it very thick and heavy. For water, the usual thickness is about $\frac{3}{16}$ in., but I do not think that $\frac{3}{8}$ or $\frac{1}{2}$ in. is too much. I have seen cast iron impellers of that thickness wear out in 4 months so so that the thinner impeller would be almost useless. This means special patterns for the manufacturer of water pumps, but it more than pays. In placing the impeller on the shaft, be sure that the liquor will not be able to get at either the key or the shaft. If it does it might cause the impeller to wobble, with results that are obvious. The surfaces should be as smooth as possible, but it is not necessary to make them as smooth as for pumping water. Most solutions will wear them smooth very quickly, and will destroy any imperfections rapidly, so that an impeller which has been used for a month will show a very much higher efficiency than the new one. I have seen an impeller which we did not take the time to polish have a capacity of 200 gallons per minute and an efficiency of 25 per cent. Four months later this same impeller had a capacity of 300 gallons per minute and an efficiency of 60 per cent. The efficiency usually guaranteed by the manufacturers of this type of a pump is between 45 and 58 per cent. In the construction of the chemist's pump various materials can be used. For alkalis an all iron pump meets the condition very well. When the alkalis are full of a precipitate a harder metal must be used. The running rings may be made of monel metal, or nickel steel.

For some solutions, we can build the pump of bronze, monel metal, hard lead, or stoneware. I do not like stoneware pumps, as the strength of the material is very low, and because of this, slow speed must be used. This means that the efficiency is low, and as I have never seen a stoneware enclosed impeller the efficiency will be very low indeed. I have never had a stoneware pump tested, but better made iron pumps took power out of all proportion to the work done. One of the problems which the chemist must always face, is the speed of the impeller. With water, and most alkalis, the impeller can be made of monel metal and the rim speed can be almost anything desired, or practicable, but in pumping acids, it must be very carefully examined. Many of the metals and alloys withstand acids for the reason that there is formed on the surface a skin of an oxide or a salt, and this is adhesive to the metal and protects it. When this is used in a reciprocating pump, the salt is hard enough to withstand the slow speed, but on the rim of an impeller it quickly

erodes, and the impeller is dissolved very rapidly. Some alloys which will resist acid for years in tanks, and pipes, will dissolve in a few hours when made into an impeller. The only way out of the difficulty, is to either use some other form of pump, or to use several pumps in series, keeping the rim speed of the wheels slow enough to leave the protecting skin in place. The multiple stage pump for chemical use has too many complicated parts in one casing. Several single stage pumps in series it seems to me are better, for then trouble can be exactly located and quickly eliminated.

Corrosion also might be from the use of different metals, causing electrolysis. With a rapidly moving surface, which is always clean and bright, electromotive forces will do far more than where sediment is allowed to collect. I have seen monel metal withstand alkali

SOLUTION 10% NaOH AND 10% NaCl

Plus.	Volts.	Minus.
Steel tube	0.55	Gray cast iron
Charcoal tube	0.15	Gray cast iron
Wrought pipe	0.35	Gray cast iron
Malleable nipple	0.25	Gray cast iron
Lunk. bronze valve	0.10	Ordinary 1-inch coupling
Ordinary nipple	0.20	Lunk. bronze valve
Nickel iron valve	0.05	Ordinary nipple
Ordinary nipple	0.05	Ordinary elbow

solutions for months, even at high speed, and I have seen a monel metal running ring worn out in a month, where a bronze ring was placed next to it. Many times, two metals such as cast iron and mild steel will have an electromotive force between them sufficient to cause trouble, and a peculiar fact is that one may be positive in a dilute solution and the opposite in a more concentrated solution. This is probably due to the fact that the change in the dissociation of impurities changes the real electrolyte. Sometimes, it is possible, by placing in the suction line a heavy thick pipe made of a metal which is electropositive to the material of the pump, to plate, and keep plated the inside of the pump, so that both the pump and the pipe will last for a long time, where the pump alone would quickly corrode. This makes the entire outfit practically of one metal, and all the

different electronegative parts become polarized, and the corrosion ceases.

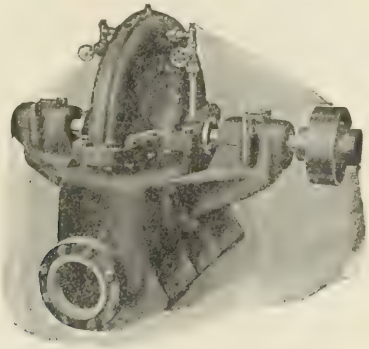

FIG. 13.—Horizontally Split, Double Suction, Outboard Bearing Pump with the Glands Water Sealed.

When handling precipitates, impellers erode very rapidly. As shown before, the capacity and the efficiency increases, and this will continue until the wheel will drop into three pieces, the hub and the

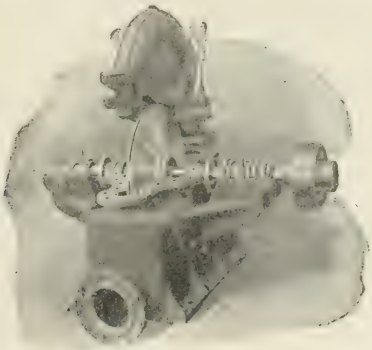

FIG. 14.—Same as Fig. 13, Showing Open Casing and Enclosed Impeller. This would be a good impeller for water and clear solutions but not good for Sludge.

two sides. As it wears, a peculiar cutting action appears on the under side of the impeller vane. This is more pronounced than on the upper side, and it cuts away the outer edges faster than the center leaving a ridge. Not only does the slot become broader, but the outside of the shroud also wears away, about in proportion to the distance

from the hub. The wearing is dependent also upon the hardness of the material from which it is made. I have not made scleroscope tests, but government bronze in alkali solutions lasts longer than cast iron, monel will last longer than government bronze, and nickel steel the longest of any tried. These were pumping approximately the same material, containing 60 per cent by volume of precipitated salts. This property of hardness applies to all parts of the pumps, the running rings even more than the impeller. In using metals for the rings, however, the selection must be made so that there will be no chance of one ring seizing the other. I have had this happen twice with monel metal.

Great care should be taken in providing the stuffing boxes with some means of preventing any possible leakage of air. When handling cold solutions, a convenient means is to place a grease cup in such a way that the packing can be filled with the grease at any time. In this way, the wear on the shaft at the packing is very slight, and no air can break the suction. If hot liquors are being handled, a connection from the volute to a lantern in the stuffing box will effectually prevent trouble, but if there is a precipitate in the liquor it is sometimes necessary to use a clear liquor from some outside source under pressure to keep the gland tight. The most troublesome problem which I have had with these pumps has been in pumping a heavy precipitate with a pressure on the suction of the pump. In spite of a large stream running into the stuffing box from an outside source, the precipitate will force its way into the packing and cut it into pieces very quickly. I have seen a $\frac{3}{8}$ in. packing, 6 rings deep cut to pieces in one hour, by salt getting into it. In pumping milk of lime, two stuffing boxes had to be repacked twice a day, because there was a pressure on the suction of the pump. I inserted a plate in the suction line of the pump, which reduced the pressure to one inch vacuum, while the pump was running, and the box did not have to be packed for a month. The question of packing has been a difficult one for me to solve. I have used asbestos, which is usually filled with some cotton. I have also tried asbestos with phosphor bronze wire, and various kinds of metallic packings, but all seem to cut the shafts quickly. The best shafts which I have used have been of monel, although I have tried cold rolled steel, government bronze, phosphor bronze and tobin.

There is one point to be made in handling sludges. They are naturally hard to pump. Many of us at first thought would try

to overcome this difficulty by using one size larger pipe. In doing this we would make a very gross error. We should use one size smaller pipe, and use a pump which will give enough pressure to push the sludge through it. The cause for the precipitate remaining in suspension, is the speed of the liquor. If the speed is not high enough, the precipitate will settle and cake. If the pipe is large the speed will be slow, and the precipitate will tend to settle out and will drag along the bottom of the pipe, that which is ahead blocking the way of that which follows. Since this is thicker than that above, it will not travel so fast, until it cakes and fills up the pipe to the point where the speed will overcome the settling action of the precipitate. Therefore, it seems to me to use the smaller pipe, using a higher pressure at the pump, and move what was intended is better than to use a lower head pump, and let the pipe fill up, which gives a rough surface, and then one has to pump whatever the piping might allow. I have seen horizontal pipes which were carrying hot sludges so hot on top that the hand could not remain on them at all, but comparatively cold on the bottom.

The chemical engineer has to contend with a variable viscosity. This is of far more importance when using a centrifugal pump than in using a reciprocating or rotary device. The mechanical losses in the centrifugal arise from several causes. Among these are mechanical friction, liquid friction, back flow, shock, and eddy currents. When handling water, these each assume some particular percentage of the total loss. A more viscous substance changes, both the total and the different component losses. For this reason pump manufacturers will not guarantee the efficiency for anything but water. In both cases the mechanical friction will remain the same for equal loads. There will be a much larger liquid friction due to the fact that the liquid will not flow through the impeller nor allow the impeller to revolve so easily. The back flow will probably be slightly less, due to the friction of the slot. The shock and eddy current losses will be more for the reason that the liquid cannot adjust itself so easily to its surroundings. I have been hoping to be able to give you a curve which would show the relative efficiencies of the pump with which I have been working compared to the relative viscosities. Owing to the trouble of measuring the amount pumped and the necessary alterations to accomplish this, I have not been able to work the data out at this time. We may use larger piping and slower speeds if the viscous solutions contain no

sediment. The impeller should also be built to deliver at a very much slower speed than for water. In this way, the efficiency might be kept up reasonably high. In using a motor for this purpose, allowance should be made for both the higher specific gravity and the lower efficiency. When calculating pipe friction the viscosity will greatly alter the water rating.

When a centrifugal is pumping any liquid, and the head changes, as in changing from one tank to a lower one, it will not affect the working of the pump so much as one might think. Although the pipe may be shorter, and the tank lower, an increased amount of liquor will raise the pipe friction so much that the pump will alter its load but slightly. This may be a more expensive way of pumping than if the pump were made for the lower head but it makes the pump adaptable to both conditions. Frequently a pump can be designed to pump a small amount to a much higher or even a lower head than the normal rating. Each condition must be studied most carefully before installing.

There has been developed a novel pump for the use of chemical engineers which has an application where other machines fail. The most serious difficulty in handling acids is the material of which the pump can be made. A line of hard lead pumps designed like those of twenty years ago, has been on the market for a long time. They cut out very quickly, and most of the trouble is at the gland where the sleeves quickly erode so that the steel shaft is exposed. This pump overcomes all such troubles for the reason that it has no gland, nor packing, and can be made on the most modern lines. The impeller can be either enclosed or open, and it can be built for heads up to even 75 or 80 ft. The shaft is vertical, very heavy and covered with a hard lead sleeve. It is supported from two bearings placed from 3 ft. to 6 ft. apart according to conditions. The impeller is at the lower end of the shaft, overhung perhaps 6 ft. Around the impeller is a suitable casing with discharge connections. The suction opening to the casing is the novel feature. It extends upward like an open pipe for about 4 ft. The liquid to be pumped is simply fed into this open pipe, either at the top or in the side. The surface of the liquid in this pipe assumes its own form, but as long as there is any in this receiver it will be forced according to the speed and construction of the pump. They can be built of any capacity or head desired.

In closing, I want to mention an arrangement of a centrifugal

pump with direct current electric motors. We all know how a series-wound motor will operate under varying load. It changes its speed running faster as the load decreases. If in pumping sludges, we use a pump with a drooping characteristic and then use a highly over-compounded motor, the pitch of the characteristic can be made very steep. The operation of a pump under these conditions is such that a sludge may plug the discharge pipe, the quantity discharged decreases, which in turn decreases the load on the motor, which instantly speeds up, creating more pressure, and removes the plug

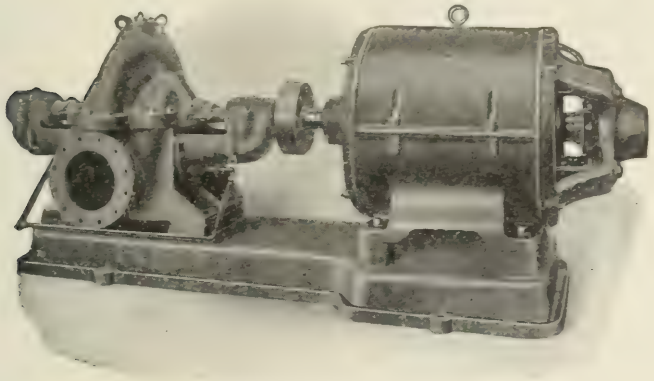

FIG. 15.—Electro-motor Centrifugal Pump of the Horizontally Split Double Suction Type.

almost before it has formed. This same idea could be applied to a pump which has a rounded characteristic. As the pressure tends to drop with the quantity on very low discharge, the horse-power will also drop, causing the motor to speed up. The result is that the shut-off speed of the motor is higher than the working speed, and the shut-off pressure is accordingly higher. If we have to pump into a tower, where the starting pressure must be higher than the operating pressure, this motor will assist in obtaining that result without using the impeller with the longer channels. Many times also, an adjustable speed motor will help us to obtain that flexibility of the steam pump, with the advantages of the centrifugal, with a speed variation of less than 40 per cent.

Discussion

Dr. F. W. Frerichs:

Would it be feasible to publish with this paper the tables which you say are in use by the manufacturers of centrifugal pumps? Such tables might be useful if one has to construct his own pumps.

Mr. Wheeler:

These tables to which I referred would be absolutely useless to one who is not thoroughly familiar with the design of impellers. Beside this they would be so extended that to give any definite information from them would be beyond the scope of any one paper, and would extend almost into volumes. From the formulæ which I gave can be calculated in a general way what an impeller may do, but after an impeller has been built, it should be tested at about four different speeds at each of six or seven diameters. Then repeat the same with other impellers built the same except with the slot a little wider, etc. This will give about 200 sets of three curves each, viz., head-gallons, H.P.-gallons, and efficiency-gallons. This is with one curve of the impeller. By altering either the suction angle or the discharge angle of the vane you have another curve, and another complete set of curves, viz., about 200 more. You see that this begins to reach enormous figures. Also an impeller pattern is worth about $25, and an impeller finished will cost as much as $50 if only one is to be made. From this it is seen that a set of curves will cost several thousand dollars and applies only to the particular curve of vane which a certain blue print describes. Any outsider who did not know that curve would not be able to use the performance curves. These sets are made only as pumps are purchased, and may be more or less complete according to what pumps have been purchased from the particular manufacturer. The real commercial aspect of centrifugals is really one of give and take. It is a sort of scientific guesswork based on previous experience. I understand that one company has literally thousands of curves to choose from. Another has spent as high as $50,000 to make out their set, and then made a very unsuccessful commercial pump.

The builder who wants to build his own pump, can start on what I gave and then make a failure or two before he gets what he wants. Personally, I have five impeller patterns for one pump. I have about 12 performance curves for each pattern. This is for

only the one size pump. In this way when I want to pump hot water or a sludge, I multiply the factor of one certain curve which I think will do by a factor which roughly represents my experience with that liquor, and get approximately what I want, I put this machine on the test block, and then test and adjust it until I get what I want. Sometimes my first guess is all wrong, and I have to lay out an entirely new impeller. This was the case a short time ago, when a firm sent a motor at 1200 R.P.M. instead of 1050. I took my 1050 impeller and turned down the periphery so that my peripheral speed was the same. The result was an efficiency of about 25 per cent. I had to use an entirely different impeller, larger in diameter, but with a smaller angle between the vane and the tangent at the rim. Also with a wider slot. This will give you an idea that the centrifugal is a very muleish machine. You see naturally firms do not let the curves go out of their shops.

SYMPOSIUM ON THE UNITED STATES PATENT SYSTEM

THE INSTITUTE AND THE UNITED STATES PATENT SYSTEM

BY WM. M. GROSVENOR

Read at the Chicago Meeting, June 23, 1911

One of the objects of the Institute is to suggest or properly influence legislation in any field wherein as a body its members are experts.

One of the most important is the "patent field," including the laws and rules of practice and custom under which patents are applied for and secured, the means of ascertaining what has been done, methods of publishing current patents, what the allowance and publication of a patent does and should mean to the public, to the capitalist and to the inventor, also methods of ascertaining and defining the relative rights of the parties concerned and preventing, or proving and compensating infringement; what character of evidence is desirable, the best method of securing such evidence to assure its value and pertinence,—broadly speaking, all the subjects which come under the common heading "our patent procedure." These are the subjects of legitimate interest to members of the Institute from almost every point of view. All of our members are consumers, many are manufacturers, nearly all are inventors, some are patent attorneys and many serve in one field or another as patent experts. There is probably no member of the Institute who has not had personal experience with either the Patent Office or the Federal Courts and it may probably be said with perfect safety that there is not one of us who is satisfied with the present procedure.

A number of other societies have deliberately set themselves the task of doing what they could to improve the situation. One has been organized particularly for this purpose. We should certainly be qualified to judge, it is to be hoped that we can exercise some influence, and certainly our responsibility in the matter is as great as that of any other scientific body.

Without trying to chose between "the hen and the egg" or to decide whether the inventor is responsible for his idea, or an idea comes floating along like a germ and possesses an otherwise respectable citizen making of him an "inventor,"—let us begin with "the combination which consists of the idea, the inventor, (generally without 'means') and the difficulties of existing conditions, to improve said conditions."

The first difficulty is the haziness of the idea, the habitual looseness and inaccuracy of our methods of thinking. For this, legislation has no remedy and only by our personal effort, self training and example can we be directly helpful. A clear cut analytical digest of prior art would set a fine model for distinctive thought, but we must ourselves form, and help our clients to form, as their attorneys are daily helping us to form, clear precise mental images of the essentials of an invention, that are as simple and as near a "state of absolute natural nudity" as possible before undertaking to clothe them in the simplest and most accurately fitting language that can be found. If the final bare invention as we see it, after stripping it down to its absolute essentials, is no longer novel it is not worth patenting (except perhaps as one picket in a patent fence to be supported by stronger posts). On the other hand the "element of invention" is an illusive quality, depending much on the point of view and method of arrangement or presentation (an element which the mind untrained in patent work can scarcely weigh). The catch-penny solicitor trades on the layman's uncertainty and enthusiasm in reaching this decision. We can urge certain steps to discourage and eliminate such solicitation.

Having clearly thought out an idea and separated the non-essentials, and decided that it appears to be novel and worth while, the next step is to establish date. This could formerly be done by the filing of a caveat, but the value of doing so was questionable, and the statute has been repealed. In the absence of actual practice of the idea, a caveat was extremely difficult to draw broad enough to properly protect the idea and yet accurate enough to differentiate the patentable novelty. The time, thought, and money required by a proper caveat would frequently have served to protect the idea in the best possible way—execute it, or reduce it to actual practice. This frequently requires the cooperation and assistance of others—and many inventors shrink from anything of the kind. One well-educated man who had made numerous inventions so far

misunderstood the case as nearly to lose an invention simply because he feared to reveal it fully and frankly to his attorneys and it later required no little ingenuity to devise apparatus to carry the specific illustration out properly and prove that it was operative in the hands of anyone skilled in the art and provided with suitable apparatus. Had he kept proper witnessed records of his preparatory work or had he delivered his description to the attorneys in writing and taken their acknowledgment on a duplicate copy—no anxiety need have been felt. The simplest manner of establishing date or priority as against any individual is to take an acknowledgment in writing that he has no invention of the general character in question and has received in confidence the attached disclosure of invention from the inventor. In cases of considerable importance the signature may be attested by a notary to avoid possibility of question in case of death. Records made in the crudest manner provided they are detailed accurate, dated and show diligent effort to perfect the idea and reduce it to actual practice are the best evidences of priority and are practically impossible to falsify against cross-examination. Conditions in this respect could hardly be improved, and the trouble lies with the inventor that he frequently does not know how (or take the trouble) to keep clear records.

The best preliminary protection for an idea is to use it—to put it into practice in some way as quickly as possible, for after all whoever first does the thing is entitled to the patent (provided he does not sacrifice his right by lack of diligence, by secret use without improvement or application for a patent, or by two years' public use and sale). There are two ways of doing this—actual and constructive. Actual practice when possible has every advantage. It actually begins the great task of introducing the idea, it serves to enlighten as to essentials, to define the scope and show the real value of the idea, it suggests modifications and improvements and for two years after the completion of the clearly experimental work is all the protection of a patent application and is, if anything, better protection in case of interference. For a reasonable period, six months or a year, it may be well to use it quietly though not necessarily secretly in order not to advertise the date of invention in case of interference, after which, for nearly two years, public use and sale only serves to advertise and assure title without fear of injury or or loss. Public use has a further advantage in that an enormous amount of light is thrown on the prior art by almost everyone who

considers the idea. Numerous criticisms and suggestions aid greatly in gauging the real essentials of the idea, as well as the possible methods of substituting or modifying it, and its value. During this time, however, it is well to keep record of every change in design, construction or method of operation. This information is of great assistance in drawing the patent application and framing the claims and should all be noted in the record of the idea, together with the dates and the sources whence suggestions arose. Such a record is invaluable to the attorney.

Within two years, however, of the first public use and sale that is not clearly experimental and tentative, an application for patent should be filed if the inventor's rights are to be secured and, as the proper preparation of an application requires study and time, two or three months at least should be allowed.

Some ideas of great value are hardly within the power or means of the inventor or his confidential friends to put into actual practice. They may involve great investment or be adjunct to expensive manufacturing plants or processes into which he cannot gain entrance. The application for a patent then constitutes a constructive reduction to practice and should be resorted to early, leaving the inventor free to discuss his idea, present it to manufacturers or investors and show that diligence in his effort to place it before the public which it is still desirable to prove, in case of interference. This constructive reduction to practice in the absence of actual experience with the idea is often a difficult and dangerous method at best, unless the idea is connected with the special experience of the inventor or with practices of every day life when actual reduction is easy. The proper drawing of the application involves accurate foresight as to the action of untried factors under conditions more or less unknown, and to be worth while demands almost of necessity the advice of an expert in the particular field involved. Generally speaking "inventing" is a waste of time except to meet a specific demand of the inventor's own business where it is rapidly reducible to actual practice, or else in a field where past experience has made him expert; applications for patents on other "ideas" are too often a waste of time and money. There are exceptions but they are emphatically exceptions.

This brings us up to the point of applying for a patent, as the result of experience and thorough trial or as a constructive reduction to practice, to the relation of applicant and his attorney. The choice of his attorney is the most important act of the inventor. A

brilliant and valuable idea may be so garbled or limited in description or claims that the patent is simply worthless, or a narrow idea, almost worthless in its present form, may be so developed and broadened that not only will it have a value of its own but the patent secured to cover it may later cover the entire gateway to a new industry. Like every other form of service patent service is a matter of price. Good work is never cheap. But many ideas even after reduction to practice on a moderate scale are still of uncertain value. We should recognize and point out that if it is worth patenting at all, it is worth patenting well. But can it be patented? Only a harmonious body of patent decisions and complete classified knowledge of the state of the art kept up to date would enable anyone to tell. Right here is the point where proper legislation well executed can do more perhaps than at any other place or all other places to improve the situation. Some of the legislative methods suggested for obtaining these decisions and disseminating this knowledge will be discussed shortly. Their important bearing on the choice of an attorney will be instantly recognized. With logical decisions and a readily acquired knowledge of the prior art an expert opinion as to patentability, by the best patent attorney, could be quickly formed and would not be the almost priceless thing it is to-day, when years of study must go to the vaguely defined prior art and contradictory decisions before it can be certainly formed. The opinion of an honest and expert attorney would then be formed with reasonable labor and would be equal to that of the patent office and almost equal to that of the courts. Such an opinion could be formed in advance of the labor of prosecuting an application and would be nearly as cheap as the services of the catchpenny attorney that now infests the land, advertising the impossible and the absurd, which is accepted only because the sane alternative is too expensive. No patent solicitor who guarantees "a patent or money refunded" is honest with his victim. "A" patent will be secured, not that protection which the word patent means to the victim. And no intelligent man doubts that he is playing against loaded dice when he goes to an attorney who "charges fifty dollars," or one hundred dollars, or any fixed sum. The intelligent man knows that the patent solicitor is not working for amusement and that any fixed sum pays for only a certain amount of work of a certain class with a moderate allowance for compensation by other jobs. Beyond this point the solicitor stops working and gets a "patent," if he gets anything at

all, by dropping in the little limiting phrase which emasculates the patent and makes it easy of allowance—and worthless when issued. But under existing conditions, in entire ignorance of whether the idea is new or hoary with age, in the absence of any defined state of the art, some cannot afford to undertake really expert service in patent solicitation. Good things deserve careful protection. One application filed two years ago paid the solicitor about $400 for his part in its first preparation and the two advisory experts much more. Since then not a single claim has been allowed and it is doubtful if anyone knows just how much it has cost. But the prior art was well studied before filing, and the application will be allowed by the Office or by the Court and when allowed it will be a patent worth having.

Unfortunately the relation between inventor and solicitor is too frequently based on a misunderstanding and it is surprising that the results are as satisfactory as they are. The average inventor goes to the attorney in much ignorance, some awe, and the first time with no little suspicion. Your doctor, your lawyer, and your father confessor, if you have one, stand in a class by themselves. That absolute confidence between the two is a fundamental necessity goes without saying and yet many solicitors make it impossible. The suspicion is inevitable of any man who advertises to refund your money unless he demonstrates the novelty of something which is yet unknown to him or a man who agrees for a certain fixed price to do an indefinite and perhaps impossible thing. Even the inventor, who does not know the facts of the case, generally knows intuitively that he is dealing with a man who is " holding out " on him and deals likewise. Even when the solicitor is perfectly frank and honest in these matters and explains that he can only work on a per diem basis and do the best he can without any assurance of success, there is often another cause for suspicion in the misconception by the inventor of the functions of a patent attorney. Many intelligent and well informed people regard the patent attorney as the supplement of everything which the inventor lacks. It is the general impression that an inventor should be able to go to the attorney with his idea more or less clearly developed and intelligently understood in his own mind, with some slight knowledge of the prior art and find in the attorney an expert in this particular field, whatever it may be, who is familiar with the prior art and capable not merely of grasping the vague idea but of determining all the novel features

of the invention, presenting it clearly, also expressing accurately the distinctions between it and what any other human being has previously done in the same lines. In addition to these abilities, the patent attorney is sometimes expected to have the commercial knowledge and experience to advise as to the value of any kind of invention, in many cases to be a promotor. As a matter of fact all that can properly be expected of the attorney is to know the best methods of application and legal protection, in a field almost wholly dependent on precedent, sometimes contradictory and therefore mutable as the sands under the wind of each new decision. The fact that some successful patent attorneys manage to a considerable degree to meet all of these requirements is a flattering commentary on the men who stand at the fore-front of that profession.

But all this the inventor rarely, if ever, finds in his solicitor and he unconsciously fails in complete confidence because he is dissapointed and uncertain. He may never quite get over the feeling that patent soliciting is a one-sided game (as it sometimes is), and he unintentionally makes it so in the opposite sense when there is no just cause. As a matter of fact, the good patent attorneys as the expert knows them, command the highest admiration and esteem. Any improvement in court practice that will harmonize precedent and in facilities that will make it possible for such men to quickly select the art bearing on a proposed application, will go far toward placing the opinions of such men within the means of the ordinary inventor, eliminating the catchpenny solicitor and with him all the mass of worthless stuff that is brought to the Patent Office, less because of its value or novelty than because it furnishes a means of livelihood for such solicitors.

Where a patent application is being actually prosecuted by a large corporation through the personality of some one of its technical experts, the inventor supplies the idea, the other technical men of the staff cooperate with him in reducing it to practice, and determining what is essential and valuable as distinguished from the penumbra of personal prejudice, contribute their knowledge of the prior art, sift the essential novelties from the prior art and contribute largely to intelligent understanding of what is actually being done and what is necessary to be done. In such a case the patent attorney's function is practically limited to the phrasing in acceptable form of such steps or characteristics as are really essential and the linguistic differentiation (according to the rules of practice)

of these essentials from the prior art as presented by the company's experts or the Office; he contributes much, if not all, of the profound knowledge of the English language and the interpretations of courts which is so essential to good patent work and which sometimes enables the mere choice of a phrase to broaden enormously the scope of the claim. He conducts the arguments with the Office, preserves the file wrapper from objectionable records and makes it his business to so express the application that the patent, when issued, shall be open to as few points of attack or misinterpretation as possible. This in itself is no small task and the entire value of the patent may depend on proper punctuation, proper choice of words and proper definition in the specification of the sense in which some special word or phrase is used in the claims.

When the inventor is a private individual or acts for a small company lacking a varied technical staff, there is likely to be a wide gap between him and the patent attorney—unfortunately is too often unrecognized. One firm of patent attorneys, wherever the value of an invention or the importance of its protection may be considerable, makes it a practice to recommend the employment of a consulting expert in the particular field to advise with them in the prosecution of the application. It is the duty of this expert to bring to bear on the case the invaluable independence of viewpoint, to ascertain the actual, as well as the published prior art, to advise as to probable lines of infringement and substitutes, to accurately define and explain what is essential to the invention and to conduct such tests and experiments as may in view of his advice seem necessary to determine the shaping of the application or to broaden its scope. In some cases the applicant or his financial supporters cannot afford such service, but when we consider the number of issued patents rendered worthless by the limited points of view of the client and the attorney, the necessity of such service will become instantly apparent. Recently, one of the best-known chemical engineers in the country, a man of large means and employing the best patent attorneys, secured without great difficulty a patent on one of the most radical improvements in chemical and metallurgical apparatus that has been made in a great many years. When issued, the patent was practically worthless because both the inventor and his attorneys had viewed the apparatus one side up. It was the way the thing pictured itself naturally and unconsciously to them both. The inventor was too busy a man

to sit down quietly as an expert and mentally turn the thing over and over and inside out, tabulate and analyze its elements and the variations of which they were capable. The apparatus would work just as well if turned over on its back, but the description and every claim specifically provided for the arrangement which the engineer and his attorneys visualized in their minds. When submitted to an independent expert for advice as to the issuance of other patents, it was instantly pointed out that this one was worthless, a reissue was sought and easily obtained. Had the reissue been delayed until another manufacturer put in practice the modified form, a reissue would have been a very different matter. There are several men working in this intermediate field between the inventor and the patent attorney, who seem to agree that a certain imaginative quality of mind, a broad education and varied practical experience are essential to success. The more such men can unconsciously acquire of the attorney's acute analytical habit of mind, nice command of accurate English and general knowledge of law, the better, but they also have their field and cannot hope to successfully enter far upon that of the attorney.

The relations between the solicitor and the Office are almost ideal—quite domestic, in fact. Most of our solicitors graduate about the same time from law-school and from patent office examiners, into the law office of some successful attorney. There is mutual acquaintance, intimate knowledge of conditions and habits of mind and reasonable harmony on both sides of the line. The only objection is that too many of the good, efficient, ambitious examiners leave the Office.

This brings us up to the Patent Office, its methods and publications. It will be apparent on a moment's consideration that no other business involving a number of employees and the annual expenditure, to say nothing of the value of the matter supposed to be passed upon, would undertake to carry on its work without exhaustive codification or would publish its results in unclassified and indivisible form. These, however, are only two illustrations of bureaucratic methods. Until recently there has been no established classification division and at present it is believed by many to be entirely inadequate and to be making slower progress than the arts. No provision has been made for the consultation with men practically turning out the work in the various lines being classified and, so far as is known, no general attempt has been made to obtain

the benefit of expert advice. While the issued U. S. patents approximate 1,000,000—about one-third of the total patents issued in the world, and while there is also an apparently overwhelming literature to be considered, it is likewise true that somewhere in this country or abroad are to be found men who have specialized in each of these particular arts from the practical as well as the patent point of view, many of whom would willingly cooperate in order to secure a better demonstration of the patent system. Probably the cost of a single battleship would adequately cover the classification expense and the work would be enormously fruitful. If properly subdivided loose-leaf or card digests were available for general purchase in sections intelligently divided and classified, many good results would follow, some of which we have already seen. Like most questions of administration, this is partly a question of ways and means. One expert of very wide experience has suggested a reversal of the usual arrangements of patent office fees, the payment of $20 with the application and $15 on allowance. The cost of printing is practically repaid by the sale of patents and it would seem better that the entire office fee be paid in with the application and made available for the proper carrying out of the chief function of the Office, examination—the essential prerequisite of a good patent, that is promised to the inventor. It is estimated that this most simple and easy change of the law would increase the revenue of the Patent Office from $200,000 to $300,000 a year and would (to some extent at any rate) reduce foolish applications. It would increase the importance and necessity of a proper preliminary search and insure a larger number of subscriptions to the codified digest when published. It would make it more difficult for the unscrupulous advertising patent attorney to " first catch his sucker," and would pay for the Patent Office work as done rather than making a large proportion of the payment contingent on the applicant's success in going to issue. All of such increase in receipts might be specifically devoted to the work of digesting proceeding backward from date. With such digests of prior art, and clearer sequence of decisions by the courts, with the decrease in careless applications when preliminary search became practicable, with the cheap and thorough preliminary search that places first class advice within the reach of all, and with the abatement in patent applications as a means of livelihood for " solicitors," the Patent Office work and all the associated lines of effort would be incalculably simplified and purified. One other step that might

be taken going far toward correcting the abuses would be adoption by the Office of a rule of practice requiring the filing of all actions and arguments in duplicate (the Patent Office itself to mail one copy directly to the applicant in person) and requiring that each amendment give the complete and corrected claims under the heading, "claims as now under consideration," and that the Examiner in forwarding the copy of "claims as now under consideration" be required to indicate any words or phrases the meaning of which is not clearly defined or fixed beyond question by the dictionary or the specification. Thus the change of a few rules of practice and slight amendment of one portion of the law would go far to the placing of the Patent Office on an entirely new footing, and without one cent increase in the cost of a single issued patent. Also it would soon have placed at the disposal of every technical man upon payment of the reasonable cost of printing, a summary of the world's work in the lines in which he was interested that would be simply invaluable to him and to the progress of the nation's industry in other ways than patent work. It may be that these are the only points regarding the office on which it would be necessary to insist, toward the accomplishment of which we should devote our effort and influence. An entirely different attitude would pervade the entire course of prosecuting the application. No such indifferent and inconsequential actions on the part of the examiners would be excusable as the absence of an intelligent digest now permits, no such careless and ridiculous applications would be filed by reputable attorneys as the easiest method at present available of developing prior art. Many questions of novelty, at present the basis of patent appeals, would be answered by the mere publication of the digest. Many interferences would be eliminated entirely, probably by the elimination of both applications before filing, certainly by an intelligent restriction of the application to the matter in hand, instead of the deliberate loose framing of an application which is at present good policy in the absence of exhaustive information as to the prior art.

It has been suggested that the patent office be made a part of the Department of Commerce and Labor rather than the Department of the Interior. It may seem to belong properly to the activities of the former. Much of the data confidentially available from census work would have value to the Patent Office and the administration of the Department of Commerce and Labor has so far given indication of less established bureaucratic habit. With such a change, if

made, should be given to the Department Head the right to complete regrading or displacement of all Patent Office employees down to and including all examiners, with the one limitation that, in regrading, their salaries should not be reduced below their present standing; together with the right to also establish for the new grades (when later occupied by regular promotion) a new scale of compensation commensurate with intelligent service, under which the pay of a principal examiner should be not less than $5000 per annum, and no man should be permitted to fill such position permanently who was not competent and qualified by practical experience in the industry with which he was dealing. It might also be desirable that an advisory "Board of Promotions and Service Advancement" be organized, at least one-half of which should be made up of the more eminent patent attorneys having practical contact with the reverse side of the examiner's work. This is one of the steps which might be taken to minimize or eliminate the bureaucratic blight which tends to descend sooner or later on every government department. Another would be the organization of an advisory staff among eminent technical men not otherwise connected with the Office. The arrangement might be that their service be retained in an advisory capacity, that one such consultant sit with the examiner-in-chief on all cases of appeal or interference. It is possible that the mere transferring of the Patent Office to another department might of itself result in many simplifications and combinations of usefulness, as well as shortening of procedure. For instance the methods of appeal might be made first to the Examiners-in-Chief and then directly to the Court. The need for some simplification is great.

These are what appear to the writer the most important points to consider.

Interference actions can hardly be eliminated, but there should be some means devised for eliminating the time subsequent to the issuance of a patent when action in interference can be instituted. Possibly a preliminary publication for one year prior to the actual date of issuance or the extension of the life of the patent to include this probationary year in a manner somewhat similar to the German practice, might be made to terminate the possibility of all action in interference. But a means should be found to give the poor contestant some sort of a chance against the wealthy corporation. As at present carried out actions in interference may be almost indefinitely extended and one party to an interference

contest expended $40,000, merely for a judgment of a question of priority—not to apply for a patent, not to get a patent, not to sustain a patent, but merely to find out whether he had the prior right to apply for it. At this price for the first rung of the ladder, where would the inventor of moderate means land by the time his patent was granted and sustained? Various means have been suggested to reduce the expense, limit the amount of testimony and cross-examination, the number of appeals, etc., but no suggestions yet made seem adequate. The way when found should be simple, clear-cut and inexpensive. To the average inventor it makes little difference whether the cost of interference is $5000 or $40,000; either would be prohibitive and it should be possible to devise some means that will greatly reduce and in a measure equalize the burden. Geographical limitations as to w a evidence is pertinent, limitation of time as to how far back such evidence may be regarded as of substantial value and therefore admissible, some division of interest by which it be recognized that both parties are serving the public and in case of interference difficult of adjudication both parties have an equal right in the invention—all these solutions have been suggested and are open for consideration.

But worst of all is the broad, general, well-recognized fact that to-day a patent when issued is not what it purports to be, that the government of the people, by the people and for the people is not keeping its bargain with the inventor. What it issues to him as a patent is far from an assurance that he will receive any valuable recompense for his service to the people in placing on file the record of his achievement so that with his death it may not be most to the country. On the contrary, what the government issues to the inventor is a contingent liability. The patent may be declared utterly worthless and invalid by the courts on so many different grounds that it is hardly worth while to enumerate them, or it may be so far limited by interpretation of the courts that its value is reduced to the vanishing point. All the various suggestions that are offered should be considered primarily in their effect on the integrity of the fundamental bargain between the public and the inventor. On the one hand assuring to the public as perfect a record as possible of everything that is commercially valuable and constitutes a step in the world's industrial progress and the Patent Office should be bothered with nothing else. On the other hand, when such matter is submitted whether

by a private or corporate individual possessing means or without them, every effort should be made to simplify and perfect the mechanism required to insure to the inventor without question an absolute right to the exclusive use of his idea. If injustice is to be done, that injustice should be distributed in such a manner that having done his share the inventor should not go entirely without recompense.

As things are to-day the purchase of a patent even after the most thorough expert investigation is hardly to be recommended unless the price is so low that it no longer represents a fair valuation of the invention but merely the value of a patent as a possible useful club in the commercial contest. The value of patents to-day lies less in what they assure than in what they threaten. It is difficult to-day, if not impossible, to frame up an equitable arrangement by which an inventor can permit the use of his patents without both parties to the agreement taking large chances of loss on the one hand or unjust advantage on the other. The inevitable result is obstruction of progress and retarding of industry. One eminent authority has pointed out what is too frequently forgotten, that the public has certain interests in the outcome of patent litigation. The inventor has his rights, the manufacturer his, and the defendant who may be infringing believes that he also has certain rights; but of a certainty the right of the public to *be spared the expense and delay of interminable litigation is beyond question.*

This brings us to the " court." It has been frequently suggested that the court for all patent cases, whether appealed applications, interferences or infringements, should be a special court. Some effort has been made to establish such a special court or board, but as yet unsuccessfully. The number of appeals has been somewhat reduced by limitation to the Circuit Court of Appeals but radical action should be taken in the direction of providing a court rendering decisions general throughout the country. Since the elimination of the Supreme Court intolerable confusion has begun to arise between decisions in districts. One manufacturer cannot make, use or sell in New York where one of his factories is located but can in the Middle West. The right of appeal to a Patent Court would tend to restore general harmony, particularly if the special court suggested were made a Patent Supreme Court and patent appeals taken entirely out of the jurisdiction of other Federal Courts. All of the organization, arrangement, circuits, etc., of this patent court

might be specially arranged for patent service and the judges be specially selected with reference to their training and experience in technical industry as well as in that branch of law. One suggestion of rather radical nature, that might reduce expense, would certainly train the judges. This was to move the court instead of moving the evidence, exhibits, witnesses, and experts.

And now for the experts. Of necessity some portion of patent testimony either on interference or infringement is expert testimony. There are certain questions of real fact concerning which any witness who has senses may be competent to observe and testify. There are, however, other facts concerning which it is necessary to be an expert in order to testify, and the system of retaining experts on behalf of each client is an unfortunate one in that it tends to defeat the ends of justice. Occasionally the less expensive man proves the more effective, but to some degree it is a matter of number and reputation rather than a question of accuracy and fact. Some of the best experts are valuable largely through their trained ability to avoid admitting facts or even possibilities adverse to their clients. It has been suggested as a matter of economy for the client, for the court and in the long run for the expert, that the experts be called by the court, possibly selected from a joint list submitted by the opposing counsel in somewhat the same manner as a jury. Or again their number be specifically limited to one or two on each of the general issues of the case. Also that the experts be addressed and examined only by the court and that their fees be a part of the court costs with, however, the provision that at the final hearing both parties have the right to cross-examination of such experts, the cost of examination being borne by the examining party. No suggestion that renders the expert a court employee or attache will aid in reaching just decisions. No other incentive can take the place of personal ambition and profit that successful expert work offers and such a system of court experts would be wholly inadequate to delve to the very foundation of real fact and thrash out the last shred of logical argument as does the fighting spirit developed by a corps of attorneys and experts under the present system.

Regarding infringement, its punishment and detection, it has been suggested that a broad and radical step be taken and that the right of an inventor under a patent should be established both as to his percentage recompense and the scope of his patent by a

system of advertising somewhat similar to that in use in Germany and providing that if no objection is sustained during the first year of provisional issue of patent, the inventor's right to recompense for its use shall begin to run and not be delayed until the court shall have passed upon the validity of the patent. Another suggestion has been that immediately after a final verdict for the complainant, the infringer be compelled to pay all court and *expert* fees and to pay a fixed penalty for each month since the first infringement of which he was guilty, not a fixed penalty by way of damage and not applicable thereon but merely as a fixed penalty for breaking the law.

It has also been suggested that the census and other investigations of the Department of Commerce and Labor would make it possible for such a department to establish the requirement that each manufacturer be called upon to report the methods in use by him; that a Bureau similar to the Secret Service Bureau of the Treasury be established adjunct to the Department of Commerce and Labor, the special duty of which should be to follow up any indications of infringement, upon receiving the same class of information which is submitted with regard to counterfeits, the expense of such investigation to be a part of the penalty of the infringement where found.

Many such means of enforcing the right which a patent is assumed to convey, in other words of giving to the inventor what the patent law originally intended he should have in return for his revelation to the public—would become needless if there were any reasonable way of determining what is new. The digest has been suggested as the ultimate standard of novelty. It has been proposed to allow twelve months after the issue of any section of this digest, during which workers in any line may complete and correct the record by transmitting further information for supplementary publications. After which any unrecorded art prior to the issuance of the current digest be regarded as lost art and not available in the U. S. Courts as evidence of anticipation.

Which brings us back to our first proposition, digest and codify and to our second, make the payment of the entire patent fee due upon filing of application. Concerning these two there is probably not much difference of opinion among experts and even with the present personnel and established bureaucracy of Patent Office these would go far toward improving the situation. Whether

the Patent Office properly belongs to the Department of Commerce and Labor is open to discussion, but some modification of the patent practice and patent laws is certainly necessary, and it is our business to take part in, if not initiate, such a movement. The Institute is pledged to the consideration of such matters of public welfare. To such an extent as may be necessary we should take means to advise ourselves both by invitation to expert patent lawyers and by other means and should deliberately exercise our influence as a body for the betterment of conditions which we all recognize as far from satisfactory, enormously expensive, obstructionary, and unjust. We should then interest and unite with others to urge these improvements.

The method of urging upon the President that which is decided on might be first, by resolution of the Institute and by inducing direct appeal to him by influential manufacturers, state officials and lawyers urging to appoint a suitable Commission to investigate conditions and frame necessary acts. Then by personal appeal to Congressional and Senatorial representatives, by further and more intelligent presentation of the subject before this Institute and circulation of such papers among representatives, patent attorneys, magazines and newspapers.

Discussion

Secretary Olsen:

We have a communication with reference to this subject from L. Gutmann, which reads as follows:

St. Louis, June 2, 1911.

Mr. John C. Olsen, Secy.,
A.I. of C.E. Polytechnic Institute,
Brooklyn, New York.

Dear Sir:

Recently the St. Louis Section of the American Institute of Electrical Engineers passed the enclosed resolution which was sent to President Taft, who acknowledged its receipt.

To impress upon the Chief Executive the importance of the measure the support of other societies is indispensable and I ask your kind assistance in the matter. Will you endorse the same or a similar resolution?

When passed it should be sent to Washington and if convenient I would like to receive a copy of same.

In further explanation for the drafting of this resolution I will call your attention to the fact that heretofore patent laws were not corrected when they were found to be bad, but only after the abuses had become so distressing that a general discontent prevailed and a sufficient number of citizens joined hands and made such vigorous protest before Congress that something had to be done. After such laws were changed abuses again appeared in a different form and the same struggle was necessary to bring the matter again to the attention of Congress. This has gone on for a hundred years.

The enclosed resolution was passed in the hope that President Taft might create for patents, copyrights and trademarks, a permanent system of governmental supervision, a department similar to the Patent Office, which would take care of everything pertaining to such a department. It should gradually substitute good for bad or weak laws, and propose improvements to Congress with changing conditions without requiring the loss of time and labor by individual citizens and without first permitting lawlessness and abuse to reap their present advantages.

Will you kindly bring this matter to the attention of the member whose business it is to present it at a meeting, or at your convention?

Hoping for your assistance and co-operation, I remain,

Yours very truly,

L. GUTMANN.

5645 Cates Ave.

TO THE PRESIDENT OF THE UNITED STATES:

Whereas, The United States Patent Laws despite many revisions continue to cause great suffering, injustice and loss to inventors, owners of patents and the people, and

Whereas, It is very desirable to increase the security and value of industrial property by appropriate legislation,

Be it resolved that we, The American Institute of Chemical Engineers, in regular meeting assembled, respectfully request that, in the next and subsequent messages to Congress, attention be called specifically to existing conditions and the Congress be urged to establish a Patent Commission, invested with power and provided with funds

to investigate thoroughly said conditions and recommend suitable legislation for correcting the evils.

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President.

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Secretary.

The PRESIDENT:

In further explanation of this communication of Mr. Gutmann I would like to say that I had two interviews with this gentleman in regard to this matter. Mr. Gutmann has worked on this for several years, has conferred with lawyers and made a considerable study of this matter. Several months ago he presented an extensive paper on this subject to the St. Louis Branch of the American Institute of Electrical Engineers, and as a result of this paper these resolutions were drafted. The St. Louis section of the American Institute of Electrical Engineers has brought the matter to the attention of the parent Institute but action has not been taken because, as I am told, certain large concerns heavily represented on the Board of the National Society refuse to do anything to advance the matter, so that no action will be taken at the present time. They are now waiting for a change in the Board which will probably take place next fall. In the meantime the St. Louis section has gone ahead by itself. It has sent these resolutions to President Taft; it has sent letters to the Secretaries and I have seen letters from the Secretary of Commerce and Labor advising that this resolution be transferred or be presented to the Secretary of the Interior, who has to do with that matter. In order to agitate this question in a thorough manner the St. Louis section has asked for the opinions of all the Engineering Societies in the United States, and I have a list here of those societies to whom this same question is referred. There are about one hundred and fifty, and all these societies will be requested to co-operate in the plan to reform the patent law. The main thing which Mr. Gutmann advocates is the establishment of a special patent court, a court independent of the nine United States Circuit Courts in which the present patent cases are handled, such court to have a similar standing to that of the Interstate Commerce Court of the United States. The question now is what position our Institute will take towards this question. I would like to have the views of the members on that question. Doctor Sadtler, will you give us your views?

Dr. SADTLER:

Mr. President, I listened with a great deal of interest to this paper. There are points all along with which I heartily agree. It is not possible to review them now, but I might say that a very recent decision of a patent case was made by a Circuit Court judge in New York who at the end of a lengthy decision in which he tried to weigh the views of the two experts prominent on the two sides and tried to arrive at some common ground held by those men, declared his inability to interpret the points and views, and at the same time expressed his belief in the entire sincerity and honesty of the presentations made by the experts on the opposite sides. He had to decide the patent on purely legal points, and almost without taking any account of the elaborate work that had lasted about four years. He said at the end of his decision that he wanted to go on record as saying that the present practice in the United States was pitiable, and that he felt that the judge ought to be aided in arriving at a decision honestly on the merits of the case, and called attention to the practice in German patent courts whereby the court is allowed to choose an impartial expert as its advisor, to weigh with him the presentation as made by the opposing sides and to allow him to arrive at an understanding of the subject.

This case involved an intricate chemical subject. It was an adrenalin patent in which Dr. Takamine was interested. I was one of the experts and I recognize the truth of what he said. I think he tried his best to give entire justice to both sides, but he said he was unable to render a fair decision, or as fair as he could have rendered had he been allowed the services of an impartial expert called in to aid the court; he could then have reached a much better conclusion, and that has been the opinion expressed before by some of the more prominent Circuit Court judges who have had patent cases before them. That is probably one of the points sought to be covered. The necessarily biased opinions of the two sides must be in some way weighed and a common ground found. That is, of course, alluded to among other things by Dr. Grosvenor. I realize the importance of consultation between solicitors and clients. Clients frequently fail to help solicitors make an intelligible application for a patent. As inventors they are very worthy but uneducated men. A man, for instance, who has no knowledge of chemical science whatever may yet happen upon some invention. Now, that ought to be reduced to some reasonable kind of practice, and that is one of the

points which he properly refers to. I don't know whether a special patent court with powers equal to those of Circuit Court judges, entirely independent, practicing only patent law, would be a proper solution. I am inclined to think that the opinion of the New York judge was the matter that went nearest to the point, that the court needs help in arriving at decisions. There are a great many things that might be taken up, and if time is allowed I would be very glad to express an opinion at length on this matter sometime in the future.

Secretary OLSEN:

Dr. Sadtler, what would prevent a judge calling in an expert?

Dr. SADTLER:

There is no provision made at all in the practice of patent law in the Circuit Courts for doing anything of the kind; the judge is not allowed to do it. No provision is made for paying an expert, and I don't know as he would be considered as having authority to call one; he is supposed to be the one man who is to pass on the questions at issue.

The PRESIDENT:

We would like to have the views of any of the other gentlemen who have had experience in this line. Perhaps Mr. Wood would like to say something to us.

Mr. WOOD:

Well, I can't say that I am an expert in that line, sufficient to give much of an opinion, only I think a patent would be much more valuable if you could eliminate some of these legal fights they have over them. One of the statements that I noticed in the paper was that Dr. Grosvenor advised an expert patent attorney to make the application. Well, I don't see the necessity of leaving it to a patent attorney. If there is any question about it let it be decided when we come to the legal fight over it instead of having to pay so much for the application and have the value of the patent depend on the way the application is drawn up. I don't see why the invention or the patent should be lost because they don't use good English in making out the application. I think that it is easy to refer to the invention at any time and then discuss it on its merits, and not have to consider it from the way it was applied for at all. I think it detracts from the value of the patent to consider the way the application is drawn up one of the factors. Even if it is not

drawn up so very expertly, let it stand on its merits. That idea prevents the sale of patents many times. A great many people consider that a lawsuit goes with all patents and hesitate about taking them up on that account. That is the principal objection I have to the paper.

The PRESIDENT:

I believe your opinion is quite right that our patent laws are deficient, and that much improvement could be made. This movement going out from the St. Louis section of the American Institute of Electrical Engineers I believe is very important. It is being pushed by many who are advocating improvement and have made quite a study of the way of approaching the question. I have a list here of all the technical societies, and perhaps Dr. Olsen could read it quicker than I could. It will give you an idea to what extent this matter will be prosecuted. I will then raise the question whether you will co-operate with these people by designating one of your members or perhaps a small committee to co-operate in a manner which from time to time might be brought before the convention for its approval. There are about one hundred and fifty societies which will be asked to co-operate.

Dr. GUDEMAN:

Mr. Chairman, there was a suggestion made by Dr. Sadtler that I would like to comment on. I happen to be involved in a case in Canada where the court after reading the bill of particulars and seeing that it was based on a scientific question as to one part of the case, and that it would have to be decided on a scientific basis, immediately stated that he would appoint an independent court expert to assist him, and he did so. He picked a gentleman from one of the Canadian universities. This gentleman was present at all of the hearings. There came up matters of fact where experts testified and where experiments that were specially made pointed one way while statements seemed to point to the other. The court expert was instructed to make independent experiments allowing both sides to suggest experiments which they wanted made. The expert made those experiments and the attorneys on both sides were allowed to be present so that the results of the experiments were obtainable by both sides. The expert in this case had to visit the plant and was given all information regarding this plant. Some of the information they did not care to divulge to the world so that when that part of the

report referring to the practical working of the factory was turned over to the defendant and the defendant objected to its being a part of the record, the Court ordered it stricken out of the report, but the Court had seen it. After this expert gave his report it was thought by the complainant that he had not gone far enough and a second investigation was ordered. The second investigation was made in order to decide on some specific facts. The representatives of both sides were present when the investigation was made and the record was turned over to the Court and copy given to both sides. A part of the testimony was to be taken in camera and the Court immediately decided that the advising expert should be present.

The case is still in the courts. It no doubt will happen that finally the court expert will be put on the stand and both sides given the privilege of cross-examining him in regard to his report. The justice of the High Court of Canada stated that as far as the scientific part of the testimony is concerned the opinion of the expert will be the opinion of the Court. I am involved in that case as an expert on one side; I haven't testified and am still a little bit disinterested as far as that is concerned, but I believe that the plan will work out splendidly. It is going to give both sides an absolutely square deal. We both recognize that the expert is absolutely capable and honest. I believe that something of this kind should be incorporated in the resolution giving the judges in the trial of patent cases the right and privilege of appointing their own expert. It will help patent litigation tremendously.

In regard to the fees of the court expert, as I understand it, they must be borne equally by both sides irrespective of how the case is decided. That is perfectly fair as he is acting for both sides or for neither side.

The PRESIDENT:

Dr. Gudeman has just explained to us what was actually contemplated by the St. Louis Section of the A.I.E.E. The main action which this society would like to have taken is in regard to the establishment of one court for the United States. At present the United States is divided up into nine districts and any patent case decided in one district can be brought up again in another district and may be decided in the opposite way. This society wants to obviate this, and have a court established similar to the Interstate Commerce

Court, giving it authority to select experts in a similar manner to the court Dr. Gudeman described.

Dr. GUDEMAN:

Well, I say as a preliminary step the courts should have that right. I am not talking on that resolution now. Let them first have the right to select experts and then if they have a separate court similar to the Interstate Commerce Court, why that is another consideration.

The PRESIDENT:

That would be a matter to be considered. The whole subject requires further discussion which may lead to important action. The question before us to-day is whether we would be willing to take part in this movement or not.

Dr. GUDEMAN:

To bring the entire matter directly before the society, I move that we endorse the resolution prepared by Mr. Gutmann of St. Louis.

The PRESIDENT:

Gentlemen, you have heard the motion. Is it seconded?

Prof. WITHROW:

I second the motion.

Dr. SADTLER:

Would it not be well to amend the motion and appoint a committee to prepare resolutions along the same line. I think Dr. Grosvenor ought to have a chance to co-operate in the presentation of our expression because he has gone to the trouble of reviewing this whole subject. I think it would be well to appoint a committee, and have Dr. Grosvenor on that committee. We could present a more general and fuller expression of opinion covering a wider range of subjects. Having had this paper I think we ought to go into the subject more deeply than merely pass a formal endorsement. I think we ought to take time to do this in a manner that will reflect credit upon us.

Dr. GUDEMAN:

Mr. Chairman, I will withdraw my motion if it is satisfactory to the second, and give Dr. Sadtler an opportunity to present his views in the form of a motion.

The PRESIDENT:

Dr. Sadtler, will you formulate your views in a motion?

Dr. SADTLER:

I move that the President be authorized to appoint a committee from this Institute, recognizing Dr. Grosvenor, who has worked on the matter already, to prepare an expression of our views in regard to the recognized evils of the present patent practice (its evils are not simply one, but several, and I think we ought to cover several at the same time) and then that our action could be communicated to the other societies, and also sent to President Taft.

The PRESIDENT:

How many members would you suggest be placed on this committee?

Dr. SADTLER:

Three would be enough.

Dr. GUDEMAN:

I second the motion.

Motion unanimously carried.

The PRESIDENT:

I will name the committee later on.

SYMPOSIUM ON THE UNITED STATES PATENT SYSTEM

Washington Meeting, Dec. 22, 1911

Dr. L. H. BAEKELAND, President, in the chair.

The *President*:

Yesterday, at the banquet you were told by the United States Patent Commissioner that the principal reason why no progress has been made in the matter of patent legislation, is that the inventors themselves do not take a sufficiently active interest in this matter. What is worse, every inventor has a remedy of his own, and no two of them agree on the subject. Most of them recommend unattainable reforms, and in the meantime, forget that by concentrating their efforts on some obtainable reforms, we could make some progress in the right direction instead of keeping up endless academic debates. It is a hopeful sign that for this meeting, we should have succeeded in securing the cooperation of the Patent Commissioner and some other officers of the United States Patent Office, as well as such men as Mr. Walter D. Edmonds and Mr. Kenyon.

There seems to be a prevailing opinion that patent legislation is merely a matter of protecting inventors, and inventors only. We hear some people speak about "the poor inventor," and the "interests of the inventor." If patent legislation were only in the interest of inventors, it would be class legislation, and it would be as unfair, as unwholesome, and as undemocratic, as any other class legislation. But good patent legislation is not solely for the interest of the inventor: it is for the best interest of the nation, and no nation has benefited more by its patent system, than the United States.

Compare the industrial development of such nations which have liberal patent legislation, like the United States and Germany, with that of the Latin countries where patent laws are less carefully drawn.

There is one country in Europe, Holland, which up till a few

months ago had no patent law whatever, and allowed the unrestricted use of any invention. This ought to have been the paradise of infringers. It would have been easy enough to use freely in Holland, processes patented in other countries, and to distribute from there, infringing goods to all countries of the world. Yet what was the result? Holland, with its highly developed commerce, its abundant money supply, with a race of intelligent and enterprising men, remained industrially undeveloped, and still ranks as one of the least industrial countries of the world. Why? Because there was no incentive to saddle oneself with all the risks and outlays of starting a new enterprise or improving methods of manufacture, and to know beforehand that in case of success, one's neighbor could simply do the same thing without any restriction whatsoever.

This standpoint that good patent legislation is for the benefit of the nation, is too often lost sight of; every good citizen of this country should help to improve our patent laws and the administration thereof. A patent is simply a contract between the nation and an individual, the inventor. By that contract, the inventor discloses to the community at large, the results of his intellectual work; by doing so, he enables others not only to get acquainted with his work, but to improve thereon, and he stimulates further research and invention. You will find that newly disclosed patents are usually followed in rapid succession by several improvements thereon, conceived by others, but patterned on the original invention. The inventor, in thus disclosing his secrets, confers directly a benefit on the nation, and the nation, in return, gives him the privilege of the sole use of his invention, but only for a limited number of years, and thus stimulates invention and enterprise. Practically, this is a business contract, just like any ordinary business transaction.

Up to this point, everything goes well enough, and the patent laws of the United States, as framed, are considered a model the whole world over. Unfortunately, it is in the application of these patent laws that the serious trouble begins; it is there, where the inventor does not get "a square deal," for the simple reason that the nation does not carry out its end of the contract, and does not protect the inventor. Patent litigation, as it is conducted now, is overwhelmingly in favor of the party with a well-filled purse, who can use to advantage all the uncertainties, all the slowness, all the dilatory methods, and all the complications which the law allows him, to tire out his poor opponent.

In Germany, it takes somewhat more trouble to get a patent, but once you have obtained your patent, you possess something worth having, and infringers will not recklessly enter your field, because in that country, an infringer is dealt with exactly as if he were stealing or damaging your property. In Germany, patent suits are ordinarily quickly decided and are not very numerous. In England, patent infringements are dealt with in the same practical way, which prevents long-drawn-out suits. We all know how absurdly long it takes to settle a patent suit in the United States, and how tremendously expensive a suit of the kind can be made, and how unreliable and uncertain the court's decisions are, not to speak of the uncertainty of collecting any damages, even if a suit has been settled in your favor.

Mr. Edwin A. Hill:

Mr. Chairman, I am here as the representative of Commissioner Moore. As I stated to you last night at the banquet, grippe is confining him to the house. Arrangements, however, will be made by which he will receive you at the Patent Office this afternoon, and if it is your pleasure to hear the paper read which he has prepared, I will be very glad to read it.

The President:

I regret very much to hear of the indisposition of Commissioner Moore, and accept with thanks the offer just made by Dr. Hill.

THE UNITED STATES PATENT OFFICE

E. B. MOORE, Commissioner U. S. Patent Office

Read at the Washington Meeting, Dec. 22, 1911

THE fundamental statute upon which the Patent Office is founded, and around which its entire system of highly specialized legal procedure is centered, provides that any person who has invented or discovered any new and useful art, manufacture, machine or composition of matter, etc., may, subject to the various conditions and restrictions of the act obtain the exclusive use of his invention or discovery for the period of seventeen years from the date of the grant; and the term compositions of matter is broadly construed to cover not only mere mixtures, but pure chemical substances as well.

That the chemical engineer is interested in compositions of matter in this latter and more restricted sense of " pure chemical substances " goes without saying, and for a few examples selected at random as illustrations of patents covering both process and product I may refer to the patents relating to the dyestuffs artificial alizarin and synthetic indigo; the remedial agents sulphonal and antikamnia, artificial musk and ionone, the artificial essence of violets, carborundum and calcium carbide, and others too numerous to mention. And so likewise as to compositions of matter in the ordinary sense of the term; that is, mixtures composed of various ingredients; as illustrations of these I might name such substances as celluloid, vulcanized fiber, artificial ivory, forcite, and other explosives, as indicating that here also the chemical engineer has a lively interest as well.

In machines also he is equally interested, for is not his chief function the construction and operation of the great industrial plants wherein pure chemicals and compositions of matter are manufactured and put up in packages for sale?

Taking up next the term " machine " this word in the patent act means something more than a mere collection of wheels, pulleys,

levers and belts. It is broad enough to cover all of the vats, retorts, crucibles, evaporating pans, boilers, digesters, filter presses and other such devices with which the chemical engineer must equip his plant. In a word the term covers all of the tools of his trade, so that not only the "compositions of matter" but many of the "machines" of the patent act as well are subjects of his especial interest.

The terms "art" and "manufacture" in the act are together broad enough to cover processes for the manufacture both of pure chemical substances and of mixtures of various kinds designed for various purposes, as well as for the products of manufacture themselves; for as all chemical engineers well know patents may be granted, either for a specific substance, or for a mixture of substances if the resulting product is new and useful, or for the process of manufacturing the same or both, or for any specific device or machine used in the manufacturing process, and in addition if a new process is discovered for the production of an old and well known product the new process is also patentable.

Hence in all of the four subjects matter of the patent act, viz.: "arts, machines, manufactures and compositions of matter" the chemical engineer has as deep if not indeed, a deeper interest than any of his brothers of the civil, electrical, mechanical, sanitary, and mining engineering fraternities.

Enough has now been said to show how close a relationship exists between the Patent Office and the society which I now have the honor of addressing; and in the short time remaining to me I wish to speak first briefly of some of the things in the Patent Office and its organization which seem to me to be of especial interest to chemical engineers, and finally, in conclusion, to call your attention to the pressing needs of the office for larger and better quarters, equipment and force, and to enlist your sympathy in its behalf and ask for your powerful co-operation in a joint endeavor to obtain from Congress such relief as may seem advisable and necessary.

The things chemical in our office are not all concentrated in one division. As you are probably aware the Examining Corps is divided up into 43 units or Examining Divisions, each in charge of a Principal Examiner having under his direction a number of Assistant Examiners of various grades, and clerks; the Assistant Examiners being all appointed under the rules of the U. S. Civil Service Commission after passing an examination of the most rigid and technical character.

These examining divisions divide up the entire field of knowledge covering the ground of search, each division confining its activities to an assigned section of the entire field.

Three of these divisions are almost if not entirely concerned with work of a chemical nature, viz.:

Division III, covering the subjects of Electrochemistry, Metallurgy and Metal Founding, Annealing and Tempering, and Batteries of various types.

Division VI. The subjects of Chemicals, including Mineral Acids, Ammonia, Salines, Metalloids, Explosives, Bleaching and Dyeing, Fertilizers, Photography, Preserving, Medicinal Preparations, Sugar and Salt, etc.

Division XXXI, dealing with Alcohol and Fermentation, Ammonia, Water and Wood Distillation, Coal and Coke Mineral Oils, Oils Fats and Glue, Lime and Cement, and Heating and Illuminating Gas.

The principal examiners of two of these divisions, viz.: Dr. Ely of Division XXXI, and Mr. Lewers of Division VI, were with you as guests at your banquet of last evening.

There are in addition certain other divisions either partly or incidentally concerned with things chemical, of which I will only mention the following:

Division XV, having Artificial Stone, Clay and Pottery, Glass, Paper Making and Plastic Compositions.

Division XXXII, having Refrigeration, which includes Ammonia and other Ice Machines as well as Liquid Air Plants, and also the Art of Packaging Liquids.

So much for the chemistry of processes and products as handled by our Examining Corps. But in addition to all this, as the chemical engineer is interested greatly in the sources of power and electrical energy, questions of power economy from the commercial standpoint, and the application of the electric and other energy in ways too numerous to mention, his interest in the workings of our office it seems to me must of necessity ramify out until it eventually reaches to a greater or less extent every one of our 43 examining divisions.

Supplementary to the work of the Examining Corps is the Classification Division, charged with the work of reclassifying the patents for purposes of search, and our scientific library, with its ninety thousand volumes of technical and scientific books, journals and bound volumes of foreign patents.

Of the legal and purely clerical organization of the office, though of great interest, I have no time to speak in detail if I am to reserve any time whatever to the subject which is nearest to my heart, that is to say the present needs of the office. I will, however, merely refer by name to the jurisdiction of the Board of Examiners in Chief and of the Commissioner and his assistants acting as successive Courts of Appeal from the actions of the Primary Examiners and the Interference and Trade-mark Divisions as completing the legal organization of the office and with reference to the Clerical Organization mention in order the Chief Clerk and his staff, the Financial Clerk, the Application Room, the Attorneys Search and Record Rooms, the Issue and Gazette Division, the Assignment Division, the Draftsman's Division, the Manuscript and Lithograph Division, and the Divisions of Publications and of Mails and Files.

And now as to the needs of the Patent Office which I can assure you are immediate and pressing, let me enumerate them briefly which is all that can now be done.

We greatly need a new, better and more commodious building in which to transact our, or better, your affairs, for our daily work is the transaction of the business of yourselves in common with the other taxpayers of our nation. We need more light and better air for our workers, more room so that they will not touch elbows at almost every movement. A more secluded location freer from the objectionable and disturbing noise of city traffic and the various other but equally objectionable noises consequent upon the use of quarters temporarily used for present emergencies and very poorly adapted to our uses. Noises under which our work is now most disadvantageously performed.

Secure storage space is also greatly needed for our valuable records (your records) where they will not be subjected to the chances of irreparable loss from fires started by the careless attorney's clerk as he lights his cigarette and throws away the match (regardless of the signs of prohibition) while passing down our corridors. We need a laboratory of tests, chemical, physical and mechanical, wherein opportunity can be furnished where necessary, for inventors to demonstrate the actual workings of their devices, where chemical processes can be tried out or physical measurements made if necessary, where machinery can be set up and operated. Where an examiner, in charge of a case, by being afforded the means of performing some simple experiment, will be enabled to throw a flood of light on

some questioned point in an inventor's specification, thereby saving innumerable time-consuming and patience-trying correspondence. We need a much larger and more commodious library; more books; duplicates of many of the more important books permanently placed in the examining divisions for the especial use of the examining corps, and additional library floor space so that all book stacks can be placed on one floor in alcoves supplied with consultation tables, thereby affording under proper supervision direct access of the public without restrictive red tape to all the volumes in our collection; and we also need for the library a larger force to properly classify, index and care for its collections. For the Classification Division more clerks and examiners for classification work and especially for the more complete preparation of the card index to chemical literature, which already contains over twelve hundred thousand cards of reference. And from year to year there always has been and probably always will be required constant additions to the examining and clerical force of the office to keep step with the constant increase from year to year of the number of patents which we annually issue.

And so I might go on for many minutes more, probably thereby wearying you and perhaps doing the cause for which I am pleading more harm than good.

And whence, I hear you say, is to come the wherewithal to accomplish all these things, the funds with which to build, equip and maintain an efficient service within a new and greater Patent Office commensurate with the dignity of the nation and these its so important interests. My answer is that the millions already collected from inventors in the years gone by in excess of the actual cost of transacting their business by the one unique department which asks for no appropriation in excess of its revenues and which amounts, turned into the treasury of the nation from year to year, still standing to our credit, are ample in amount to accomplish all these things, and as for the maintenance of the service if the office is merely allowed to expend for the benefit of inventors all of the money collected from them in the way of fees, this will be also ample for all future needs, or at least could be made so with very slight and inconsiderable changes in the fee schedule as already established.

Let me close this address in the language of the revivalist of religion:

" There is a cry from Macedonia; ' come and help us.' "

Discussion

Dr. Edwin A. Hill:

Mr. Chairman and gentlemen: I very much regret the indisposition of the Commissioner of Patents this morning. He could tell you in person so much better what he would like to say to you than can be done in the written statement which has been prepared in this exigency. As I stated before, it is possible that he will be able to come to the office this afternoon at three o'clock to receive you, but full arrangements have been made for your reception and conduct through the various Departments of the Patent Office whether he is present or not.

(Giving an outline of the course to be pursued by the Committee who will conduct the visiting delegates.)

In addition to what has been stated in the paper, if I may be permitted to say so, the present building which we occupy was built for a different kind of use from that to which it is being put at the present time. The model halls took up a very large proportion of the original space. From time to time, as the exigencies of the service required it, the models have been crowded out and the upper portions of the galleries used in storing records in a very undesirable way. The lower portions of the model halls have been turned into offices by means of thin partitions, which are not very satisfactory, and the result is a very unsatisfactory condition of affairs down there, which you can readily see for yourselves.

I want to emphasize what has been said by Commissioner Moore about the card index to chemical literature, because that is a thing in which I think you will be particularly interested; a matter which has been under my own charge for some ten years past. I am not personally doing very much work on it at the present time, except of a general supervisory nature. We have four workers engaged upon it, and we have endeavored primarily to index chemical literature rather than patents, for in chemistry we assume that the search is to a much greater extent the search of literature than in almost any other art, and the search in chemical literature has heretofore been a very difficult thing to make, so we have adopted a system of indexing chemical literature and patents by formulas; something like the Richter System for organic substances, for instance, writing carbon first; hydrogen second, and everything else in the alphabetical order of the chemical symbols. For example, antimony would be indexed as Sb, coming in that order, and not under A.

We divide the index broadly into two parts, a formula part and an alphabetical part, the latter containing an index to general subjects, such as melting-points, boiling-points, specific gravities, etc., and containing also a classification of chlorides, bromides, etc. This index you will find in the Classification Division, and I think in matters of preliminary search or in any branch of original research work if at any time any of you are engaged in a search of literature to any great extent, you will find it of considerable advantage to consult it, or have someone consult it for you. There is no charge made for consulting it. As one example of our work, for instance, we are indexing the bimonthly abstracts of our Society in some detail. Take one of these abstracts, in organic chemistry for instance; it may require from fifty to one hundred cards for an abstract of half a page length, and each substance named will be represented by both a title and a formula card in the index and sometimes by a classification card also.

The PRESIDENT:

We all feel thankful for the concise information which was contained in the paper presented by Commissioner Moore. Every one of us who is interested in chemical patents will hail with joy the announcement of that index. I think that in itself it is a great service to anybody engaged in chemical work.

Dr. LANGMUIR:

It would be a very valuable thing if there were a possibility of that index being published in the future, Mr. Hill. We need very much an index to chemical literature.

Dr. HILL:

I think you will find you have an herculean task before you if you attempt to publish it. It is housed in Yawman & Erbe sectional cases containing 15 drawers each. We have 915 of those drawers packed with about 1,200,000 cards, and we do not think we have done much more than scratch the surface, because we have not enough force fully to perform the work blocked out. Now, even if that work could be brought up to date, I hardly know whether it would be practicable to publish or not.

Dr. F. W. FRERICHS:

I should think such an index would be valuable if it is kept complete. Would it not be possible to have a copy of this index

made and put in the Chemical Club in New York, so that many of our members would have access to it? I would like to get an idea of what it would cost to have a copy made of such an index.

Dr. HILL:

I do not know what the cost would be. I do not think the office would object to having a copy made. We are doing this work as much for those on the outside as for the use of the office. Of course, we need a proper index to chemical literatures, but no restrictions have thus far been placed upon the use of it and anyone is privileged to go and consult it and make extracts from it. As far as our facilities are available, there is no objection to anyone making any copies he may wish, so if the Societies of New York wish to come down and make an abstract, I am sure Commissioner Moore would not object to their doing it, but as far as the office making it is concerned, we have not the necessary force. We have not enough force now to handle the abstracts of the English Society, and we are barely able, with the four people we have, to keep up with the abstracts of our American Society.

Dr. FRERICHS:

It was not the idea to burden the Patent Office with the cost of any such copy of the index. It was merely my idea to find out what it would cost if the Society of Chemical Engineers, or the American Chemical Society, should wish to have such copy made at their own expense.

Dr. HILL:

If they wanted to copy all of the reference cards for every formula and subject, that would be a considerable undertaking: for instance, if you take the subject of ethyl alcohol, it would take one and a half to two drawers for that alone; but if you only wished to make one card for each separate formula or title mentioned, that might be accomplished at a reasonable expense.

Dr. MUNROE:

Dr. Hill has said that this cannot well be done because of the congestion of the office. My acquaintance with the Patent Office began more than thirty years ago. In 1900, in connection with the work of the Census on Chemical Manufacturers, I called attention to the fact that Patent literature offered much information with

regard to the development of manufactures; that the development of chemical manufactures in particular is due largely to the inventions which have been made and recorded in Patents and I was given permission to investigate this matter, and as a result, with the aid of assistants, I have either directly or indirectly examined and abstracted over 20,000 patents. This has brought me into close contact with the Patent Office. I have observed it in action; in the behavior of the various Divisions and have become acquainted with the personnel and the arrangement and operation of the Office; and the one thing that has continually impressed me has been the fact that the Patent Office has never had, since I have been acquainted with it, and it has had less each year, as I have continued my acquaintance with it, facilities for doing its work. Congestion has been a constant result of the work there. I find the corridors of the Patent Office, every spare corner, in fact every bit of space there, filled with documents that have accumulated. As the Commissioner has said in the address which Dr. Hill has brought to your attention, the one pressing need of the Patent Office is more space in which to carry on its work.

I think there is nothing which any of us could do that would be of greater advantage to the inventor and to those who are working in the chemical arts, than to urge Congress to supply more space to the Patent Office. It is hampered in every direction and particularly in the classification of documents.

From the beginning I have been familiar with the work of Dr. Hill, in the work of the Classification Division which he has mentioned. I have sent many students, not only in technology, but in pure science, to consult the catalogues and indexes which have been prepared by Dr. Hill, and they are most admirable. There is nothing like them anywhere. You have suggested republishing them. It would be a very expensive undertaking. We might do it, as Dr. Hill has suggested, in a broad way, but in a detailed way it would entail an enormous expense. We have in the Library of Congress a general index to literature which is accessible to all, and this is more valuable to students. I can sit in my office and telephone to the Library of Congress and the Patent Office and get information desired relative to literature. That kind of thing cannot be produced by publication; it can be promoted by indorsing that system of indexing and its being kept up to date, which Dr. Hill has been doing.

Now I think this Society can do more for the Patent Office by urging that greater facilities in the way of space be given for its work and that this particular system of classification which applies so nearly to our sciences be promoted than in any other way.

PROTECTION OF INVENTIONS BY PATENTS, EXISTING DEFECTS AND REMEDIES

By WALTER D. EDMONDS

Read at the Washington Meeting, Dec. 22, 1911

Mr. PRESIDENT AND GENTLEMEN, I greatly appreciate the honor which you have conferred upon me by asking me to address you here. I can hardly see why I should have been selected for this. I am not a "reformer," nor an agitator, nor have I been such. I belong, I believe, to the same class that you gentlemen do, to wit: those citizens of the Republic who have accepted existing conditions, and under these striven to do the very best they could for themselves, their clients, and those dependent on them. But during the last few years it has been more and more forced upon me, as stated by Senator Borah in his memorable speech night before last in New York, that the times indicate dissatisfaction with everything in our governmental system which is capable of criticism in the direction of its preventing perfectly fair play to every citizen; and I have ventured, therefore, seeing that you insisted that I should come here, on preparing a paper which I trust will not be thought revolutionary, because I insist on nothing in it at all. I offer merely suggestions. But, as a requisite premise to those suggestions, it has been necessary for me to set forth facts, many of which are in my own personal cognizance. I would greatly prefer to have addressed you extemporaneously, but as the subject is always a delicate one when we come to an existing institution, I have ventured to put my remarks into writing, because I wish no misunderstanding, and no offense where none has been intended. While the physical needs of the Patent Office have been discussed here, there are other things which, it seems to me, require careful attention if we are to save that institution.

The importance of Patents, not only to inventors, but to National Progress, is too well established to require comment.

Our existing " Patent System " seems open to criticism as inadequate, in plan and operation, to satisfy present working requirements.

Its defects were inconspicuous while it bore the negligible load imposed by the Founders' modest needs, these averaging less than 220 patents per annum during the first forty-six years of the Patent Office. But now, increase in population, manufactures, and inventions, and the pressures imposed by unprecedented concentrations of resources, cooperate to strain the system, by over 60,000 applications, and 30,000 grants, annually, whence growing dissatisfaction with present results. (See Senate Con. Res., May 8, 1911.)

Its most conspicuous " weak spot " seems the *judicial* function exercised by the Patent Office.

Every patent recites that:

" Upon due examination made the Claimant is adjudged to be justly entitled to a patent."

Thus to a Departmental Bureau is entrusted judicial power to grant, or reject, applications for patent, to determine issues of fact and of law, in short to arbitrate the fate and ownership of property as valuable as any in the land.

These judicial powers are, by the Acts of Congress, delegated to 383 officials, viz.:

1	Commissioner	salary $5000
1	Assistant Commissioner	4500
1	Assistant Commissioner	3500
2	Law Examiners	2750
3	Examiners in Chief	3500
1	Examiner of Interferences	2700
43	Principal Examiners	2700
63	First Assistant Examiners	2400
73	Second Assistant Examiners	2100
88	Third Assistant Examiners	1800
110	Fourth Assistant Examiners	1500

The well-known duties of the 377 principal, and assistant, Examiners comprise scrutiny of the prior art, and of the form, and substance, of applications for patents, and their allowance or rejection.

Under this system, an invention capable of saving, or earning, millions, may, on the report and finding of an incipient Examiner, receive its initial, and usually fatal, rejection; and this, not because

he, or his associates, have discovered any complete anticipation; but, more frequently, because he, or they, adjudge that dissimilar priorities, *in vacuo* of each other, deprive the improvement of an indefinable requisite, termed "patentable invention."

During the twenty years, 1891 to 1910 inclusive, applications filed numbered 970,653, patents and reissues granted 558,465, which means that barely more than half (57 per cent), of applications resulted in patents.

It is recognized that scarcely any question requiring judicial determination is more difficult, more debatable, or requires greater learning and experience for its arbitrament than whether so-called "patentable invention" has been required to produce an improvement. Most fields are already so well worked that the openings left for improvement are almost imperceptible; nevertheless a microscopic improvement, there, may, and repeatedly has, revolutionized an industry to its incalculable benefit. Nothing is easier, after the inventor has disclosed such improvement, than to conjure previously unperceived "anticipations" thereof. Our true Courts, in their conclusive determinations of this most difficult question of "invention," are often, and beneficially, swayed by proof that the improvement has widely supplanted devices previously used for the same purpose. But the 377 Examiners of the Patent Office now "adjudge" annually over 60,000 applications for patent, unaided by this test, the improvements submitted, in secret, being yet too nascent for public appreciation. Notwithstanding which, and though admitting novelty, many an Examiner rejects on the sole ground that *he* cannot detect "invention," *Quot homines, tot sententiae!* Thus many an afterwards widely appreciated and utilized improvement has brought its inventor nothing, since his application for patent was untimely, and therefore unjustly, stifled.

The foregoing affords but one example of the numerous undesirable results of conferring such judicial powers on so large a body of underpaid officials.

Defenders of the present system may argue that the Examiner's rejection is not final; that the aggrieved inventor has remedy by appeal on payment of additional fees.

True, appeal lies to the Board of three Examiners-in-Chief, a tribunal of notoriously overworked and likewise inadequately paid public servants, which has, nevertheless, frequently well performed its duties, in those comparatively few instances in which an inven-

tor has had the courage, and means, to risk the ordeal. But here, again, he is handicapped by " the system." Aside from the solidarity, almost inevitable, in co-members of the same governmental bureau—he must overcome particularly the natural reluctance to reverse each other—on a mere, though controlling matter of opinion, such as " non-invention."

True also, if beaten by the Board, the now doubly rejected inventor may, on payment of more fees to government, and to his attorney, still further venture a so-called " Appeal to the Commissioner in Person." But, manifestly, it is physically impossible for that official, already overburdened by administration of the other enormous business of his office, to personally review the often voluminous appeal records. Wherefore this appeal is frequently decided by a deputy, or " Assistant Commissioner."

Finally, the now triply rejected applicant may, with delay, and at greatly increased charges, appeal to the " Court of Appeals of the District of Columbia." But the relative infrequency of appeals, and particularly the two last mentioned, testifies to the justified impression of their usual hopelessness—particularly if from rejections for " non-invention."

As per the Commissioner's report (172 O. G.,* 823–832) while during the year 1910 were filed 64,629 applications for patent, and but 35,930 granted, only 931 such, *ex parte*, appeals to the Board were ventured, only 168 to the Commissioner, and only 21 to the Court of Appeals. *Verb sap.*

The inventor's difficulty is that an erroneous trend once imparted to his application, as by its initial rejection by the Examiner, is, owing to conditions prevailing in the Patent Office, and this without any reflection on the good faith and ability of its appellate tribunals, extremely difficult, if not impossible, to overcome. No rule seems more firmly established than that adjudications below must be undisturbed unless indisputably wrong. Doubt precludes reversal of the decision of the expert tribunals of the office (166 O. G., 513).

The conclusion seems therefore justified that an Examiner's exercise of his judicial power to reject, usually decides the fate of the application, the remedy by suit in equity (R. S., Sec. 4915) to compel issuance of patent being for obvious reasons " hardly ever " invoked.

What then is the character and composition of this multitudinous

* Official Gazette of the Patent Office.

tribunal, comprising 377 Examiners thus made the arbiters of inventors' fortunes?

It is a privilege to concur in the Commissioner's hearty praise thereof:

" I do not believe there is anywhere, in the Government service, a more competent, intelligent, hard-working or efficient class of employees than can be found in the Patent Office " (172 O. G., 824).

But the inquiry here is whether sufficiently many *employees* of that *class* are actually qualified to exercise the important judicial function of *rejecting* an application, whether for " non-invention," or other cause.

Many of these Examiners have, in spite of their inadequate compensation, grown honorably old in the service. These are, undoubtedly, competent to wisely, and faithfully, perform their entire duty to the best of their ability. Would that it were physically possible for them to contact with all pending applications.

What of the remainder? Are they qualified by education, by learning, by experience, by temperament, to satisfy the requirements of one of the most important judicial positions in the land, for such is unquestionably theirs? Are they learned in the law? Is theirs the age, the experience, the stability, the ambition, the " love of the office " required? Are their transactions sufficiently open to public, or any, observation? Are they, in short, characterized by those qualifications, and environments, deemed essential for other judges entrusted with arbitrament of even less valuable rights and properties?

All " pending applications are preserved *in secrecy* " (Patent Office Rule 15).

But to determine the qualifications possessed by these Examiner-Judges for their high judicial position, note what is said in their favor by the Commissioner in his aforesaid latest report, viz.:

" The examining corps to-day is made up entirely of men who have been graduated from various technical colleges and schools, and they possess a very thorough foundation of knowledge when they enter the Office through the competitive examinations. With but a few exceptions they all take courses at some of the law colleges of Washington which provide night sessions, with the result that in about four years of service they become graduates and are admitted as members of the bar, both in general and in patent law. I regret

to say, however, that although the salaries have been materially increased in the past three years I have been unable to hold as great a percentage of this specially trained class of men as is desirable to obtain the best possible aggregate efficiency. There is still a certain percentage that separates from the service after a comparatively short period—generally when they have become most valuable. This is on account of the low salaries as compared with the inducements offered by the large corporations and established law firms (p. 824). . . . *The personnel of the force changes continually* "* (p. 826).

In view of the enormous volume of applications—64,629 last year—is it possible to expect that all, or enough, of the 377 individuals constituting this " corps," 110 of them salaried at only $1500, some emerging from school, some night *students* of the law, some treating their office as a temporary makeshift pending preferred employment by the " large corporations and established law firms," all accountable to none but a Commissioner physically incapable of knowing all that each is doing, can be trusted to correctly, judicially, determine allowance, or rejection, of rights involving millions of value?

Understand, the foregoing is not said in derogation of our learned Commissioner or of any individual Examiner.

Animadversion is directed solely against " the system's " potentiality to abort the intent of the Founders, and deprive inventors of Constitutional and Statutory rights without corresponding, if any, public benefit.

One example of this malign potentiality has recently come to the surface. From it others may be inferred, if not already known.

Recently, an Examiner was, by those interested, detected in falsifying records of a pending application with expectation of thereby controlling, adversely to the General Electric Company, an enormous business, i.e., tungsten incandescent filaments. It seems that notwithstanding association of several others with this malefactor, in his room, his falsifications nearly eluded surveillance, if any, and that the exceptional value of the inventions involved and the powerful resources of the company may be thanked for this particular instance ever coming to light. This Examiner, the alleged inventor, and the inventor's attorney were indicted and tried. The Examiner promptly pleaded guilty, testified against his co-accused and was, with the attorney, convicted, while the

* NOTE. Italics are the author's throughout.

inventor was acquitted. As a sequel the latter's applications for patent have, by the Commissioner, been canceled for fraud, and the General Electric Company enjoys whatever it is rightfully entitled to. The whole shameful story is fully set forth in the Report already referred to (172 O. G., 827–8), and in the decision of the Assistant Commissioner (171 O. G., 983–1002). Additional interest is imparted to this incident by reports to the effect that, prior to his appointment, this Examiner was an employee of said company. The company maintains a " Laboratory " for production of inventions, and a "Legal Department " to prosecute its multitudinous resulting applications for patents (166 O. G., 512).

In a previous case, marked as referred to said convicted Examiner, and involving the application of another ex-employee of the company, the Board of Examiners-in-Chief, on appeal from an adverse ruling, criticised the Examiner responsible therefor as follows:

" The Examiner cannot block the proceedings and perhaps render necessary a second interference by *a refusal to act.* It may be somewhat premature for us to assume jurisdiction at this stage of the proceedings, but the Examiner is *so clearly wrong* that it seems unnecessary to further delay proceedings. . . . The decision of the Examiner is reversed " (Recorded, Vol. $31\frac{1}{2}$, p. 192).

Again, in another appeal from the Examiner's rejection in that case, the Board, in reversing him, said:

" The rejection is highly technical and is *unwarranted* " (Recorded, Vol. $32\frac{1}{2}$, p. 34).

These criticisms were made October 18, 1905, and March 12, 1906, respectively. Nevertheless this finally punished felon continued his judicial functions in the Patent Office until " in the fall of 1907 " when, as the Commissioner in his said Report says " my suspicions were aroused, "—resulting in his conviction (172 O. G., 827).

The foregoing is mentioned merely to illustrate how impossible it is for the Commissioner, or anyone else, to know all that is being done by these multitudinous Judges in their numerous cases, and under cover of the secrecy imposed by Rule 15. Complaints against an unworthy examiner by aggrieved, or exasperated, applicants are rarely resorted to, the bearding of anything, while at all in its power, being immemorially unattractive.

True, the Commissioner's Report, referring to the aforesaid Examiner's conviction, asserts:

" This is the *first time* that the records of the Patent Office have been tampered with during its history covering a period of 121 years, and it is the *only* patent so tampered with in more than one million patents which have been granted by the United States to date " (p. 826).

This is a very sweeping, and we may hope and believe justified, statement. Very likely even an investigation by a Committee of Congress with power, might fail to expose other criminal or unlawful acts by Examiners.

But the learned Commissioner's premises for his statement seem inadequate to quiet his own misgivings. Witness his said Report, urging Congress to compel inventors, at their expense, to file, in addition to now required drawings, two photographic copies thereof, because:

" The purposes of this enactment are (1) to guard against and enable the detection of unauthorized changes in the original drawings, or abstraction of such drawings and substitution of another. . . . It may be changed and replaced *by any corrupt employee* of the Patent Office " (p. 826).

Let us glance, now, at the Examiner's, scarcely less important, judicial powers to *allow* applications. Notwithstanding the above noted high percentage of rejections, above 1,000,000 patents have, since 1837, been granted. The utter worthlessness, or invalidity, of a vast majority of this multitude seems amply attested by the fact that less than 2 per cent thereof have risked scrutiny by our actual Courts. Examination of the Federal Reporter, volumes 150 to 187 inclusive, discloses that from March, 1907, to July, 1911, the entire Federal Judiciary disposed of only 548 suits involving validity and scope of patents. In 314 of these the patent was thrown out, bill dismissed; in 234, only, were patents sustained. Meanwhile, during the same period, over 153,000 patents were granted.

These 548 suits submitted 696 patents, comprising 1914 claims. Of these, 577 claims were held void, and 554 not infringed, the total number of claims held valid and infringed being only 783.

It is thus manifested that Examiners much too frequently err even in the equally important matter of *allowing* applications. This may be, charitably, attributed to superficial searching, or to mistaken belittling of " anticipations "; but, back of all, the fault lies, fundamentally, in the " system's " imposition on inadequately

numerous, poorly paid, and sometimes insufficiently experienced "students of the law," the overpowering task of finding *all* anticipating publications, in addition to judicially determining the latter's bearing on the application.

What is the effect of this on public welfare?

Under the present "system," as previously noted, every patent recites that:

"Upon *due examination* made the claimant is *adjudged* to be *justly* entitled to a patent *under the law*,"

and it grants, *on its face*, to the applicant:

"His heirs and assigns for seventeen years *the exclusive right* to make, use and vend the said invention."

This language is perfectly clear, unconditional, and unequivocal in its meaning to any layman.

It is, however, too often, false, both in fact and in law. It constitutes one of the gravest, and most pernicious ,abuses chargeable to our Government. By its aid vast frauds have been, and are being, perpetrated,—money filched by designing knaves from deluded victims entitled to rely on the Government's word. This abominable situation is too well known, and too multifarious in its painful aspects, to enlarge upon. Witness the innumerable inventors who squander their all on the hordes of advertising "patent solicitors" who batten on it. Witness the victims who submit to exaction of royalties, or invest in stocks based thereon, or refrain from industries because thereof, etc., etc.

But the naked truth is that the grant is conditional only, and liable to be voided, any day, by any Federal Court. It is untrue, in too many cases, that "*due examination*" was made by the Patent Office. It is true that the "*adjudication*" made on such examination was a farce. And it is altogether false that the claimant was ever "justly entitled to a patent under the law."

In a recent instance, typical of many, five patents were so granted to an inventor who not only built high hopes thereon, but procured on faith thereof, from other dupes, many thousands of dollars in license fees and royalties. Brought after thirteen years of remunerative existence to the bar of a competent Judge, each and every claim, eighteen in number, of said five patents was adjudged *void*, "under the law,"and his decision unanimously affirmed by the three Judges of the Appeal Court, thus relegating the "grants" conferred by these patents to the waste paper, which they always were. For

this official scandal there is no possible reparation to any of its victims. Yet the record of that patentee's proceedings in the Patent Office discloses that the Examiner-Judge had, whether by negligence, or what not, refrained from observing, though of record in his Office, two prior patents which were unanimously held by four *competent* Judges to invalidate the fallacies by him allowed (see Fellows v. Borden Co., 180 F. R.,* 421; affirmed 187 F. R., 1005).

Other equally notorious grounds, too numerous to mention, justify condemnation of the "system's" delegation of judicial power to "Examiners."

Take the subject of "claims" for instance. As to these, there has gradually been developed in the Patent Office a labyrinth so technical as to victimize many.

Its culminating evil is that the Examiner may compel the applicant, while both are ignorant of the entire prior art, to define with the exactness of a description of real estate, the, then imagined, actual boundaries of his invention. As well describe those of a drop of water in a pinch of shifting sand!

To the claims thus untimely forced upon him the inventor is, forever after, held by the Courts.

This travesty also enables the Examiner to impose on an inventor the, then too frequently prohibitory, expense of contesting an "interference" to establish his "priority of invention." How many inventions have thus through default of the weak been garnered by the strong?

In a recent controversy between the General Electric Company and an ex-employee, notwithstanding the latter's strenuous objection, the Examiner insisted on permitting the company's inventor to make a claim as all-embracing as this, viz.:

"An essentially metallic arc light electrode comprising ferric and titanic materials."

The ex-employee was invited by the Examiner to make the same claim. To protect his invention he was obliged to comply, and contest the resulting interference. This, naturally, proved exceptionally protracted and expensive. On the voluminous record the Examiner of Interferences awarded priority on that claim to the company. The ex-employee appealed to the Board, which affirmed the Examiner. Undismayed, he appealed to the Commissioner in person, only to be again beaten by the latter's Assistant. Finally

* Federal Reporter.

he appealed to the Court of Appeals, the ultimate tribunal, and this, most exceptionally, reversed all the Officials of the Patent Office and awarded him priority on that claim (166 O. G., 511).

Has it been allowed him? No. Notwithstanding said award, the Examiner now rejects that claim " in view " of what he " judically determines " is:

" A serious doubt expressed by the Court of Appeals as to the meaning to be given to the word ' metallic.' "

After four years of costly litigation, this unfortunate may be obliged to retrace his weary way by appeals, and so on indefinitely.

Meantime, and since the decision last referred to, the Examiner has allowed to his competitor, the General Electric Company, its application in interference, on which has been issued Patent No. 1,010,402, containing a claim as follows:

" 1. A metallic arc light electrode yielding an arc in whose spectrum titanium and iron lines predominate."

No charge of unfairness, or impropriety, is here, made against anyone in this connection, but such situations, however honestly created, may serve to explain, in part, the undeniable, constantly increasing, evidences of public dissatisfaction with the working results of our present patent " system."

This sentiment has now so far advanced as to even menace Protection of Inventions by Patents.

Three bills are now pending in Congress, which, if enacted and upheld, will render patents substantially worthless.

One (S. 2116, H. R. 8776) confers on the Commissioner of Patents the right to issue licenses under any patent to any applicant upon such terms as he, the Commissioner, deems best. It also provides that any patent on any improvement shall expire on the date of the expiration of the original patent.

Another (S. 2168, H. R. 2930), provides that every patent shall be void whose owner may have violated the so-called Sherman anti-trust act!

True, such straws indicate the direction of the *wind;* but it must be remembered that, even these failing because of unconstitutionality, Congress possesses, through the Constitution, exclusive power to limit the terms of future patents, or even prevent them from being granted.

The present therefore seems a propitious, if not urgent, moment for timely endeavors to save so beneficent an institution.

To that end, suggestions, submitted with diffidence to those qualified to determine their merits, seem in order.

Among these, one seems entitled to particularly careful consideration.

It consists in substituting for our present system, substantially that which now obtains in the Republic of France, and which, ever since 1844, appears to have worked there satisfactorily, notwithstanding changes in Government.

The French system vests no judicial power in officials entrusted with the issuance of patents. They are granted, for the term of monopoly, to anyone who applies therefor and complies with the legal requirements, to wit, payment of fees on issuance, and of an annual tax thereafter. Another essential requirement is the filing of a description of the alleged improvement, which may, or not, at the applicant's option, contain " claims."

The ultimate fate of the French patent, its validity, its scope, or " claim," the nature and extent of its monopoly, every incident in its favor, and every defense thereto, are all left to be judicially determined and adjudicated *by the Courts*, should the industrial value of the patent lead its owners to sue infringers, or any aggrieved citizen to sue for its cancellation.

The inventor is thus spared the double burden of litigation so often required here, i.e., one in the Patent Office to get his patent, and another in Court to enforce it.

He gets all his rights, if any, by a single suit in a *real* Court, and, what is equally salutary, his patent may there also, at suit of anyone, be canceled on proof that he is not " justly entitled thereto."

About such " adjudications," unlike those of our " Examiners," there is nothing *ex parte*, secret, incomplete, or merely presumptive. All parties are in open Court, the inventor, the infringer, likewise the public, by its attorney. Full opportunity is, once for all, accorded to everyone to present every consideration for, and against, the patent and the decision of the Court is correspondingly final, effective, and fair to all.

Here the inventor may exhaust his resources in litigation within the Patent Office, without opportunity accorded the future infringer, or the public, to present all possible defenses. But, although emerging victorious from that conflict with his patent bearing on its face too often flagrant misrepresentations previously alluded to, the

inventor has only begun his battles. Ultimately he must, to enforce that patent, try everything all over again, and more besides, in a *Court*. That he may, shielded by our laws from aggression, temporize this evil day, meantime collecting royalties is of doubtful value to him, and proves too often a disgrace to a Government and a system " which permits " such possibilities for iniquity.

The French system on the other hand not only precludes such double burden on the invemtor, but its patent also precludes any deceit or oppression thereby.

It tells the truth—not only to the patentee ignorant of legal subtleties, but also to the innumerable brotherhood of potential dupes.

It specifies, on its face, that the monopoly thereby conferred is " without guarantee by the government." It expressly states that the patent is delivered in conformity with statute which provides that " patents for which application has been regularly presented shall be granted without examination of the prior art, at risk and peril of the applicant and without guarantee of either the reality, the novelty, or the merit of the invention or of the truth or accuracy of the description " (Law of July 5–8, 1844, Art. II).

The limits of this address preclude more extended discussion of the arguments *pro*, and, if any, *con*, this French system. As attested by the admirable brevity and conciseness of the laws enacting it, contrasted with the multifariousness, prolixity and dubiety of ours and their cooperating 213 Patent Office Rules, it appears perfectly intelligible to laymen, direct, definite, and devoid of pitfalls and opportunities for mistake, oppression, or fraud, anywhere, or by anyone.

It may seem objectionable, if at all, because too drastic to the infringer, for whom it provides punishment criminally, and to the inventor whose patent is exposed, even from birth, to attack by civil suit. But these provisions, on the other hand, make strongly for respect and popularity among " the wise and the honest "—the infringer having nothing to fear, if the patent be truly bad, nor the inventor if his patent truly good. Possibly a few years allowed the patentee within which to start his invention industrially, before exposing it to attack for cancellation, might be fairer.

However, by the French system, we have everything done in the open, and by the simplest and most intelligible machinery.

French applications for patents cannot, for years, crawl unseen,

like Selden's here, to emerge and coil at last round industries long established by the energy and capital of others (172 F. R., 923).

As well held by our learned Commissioner of Patents in his latest report:

"The very purpose of the patent system is to place at the service of the public at as early a date as is practicable inventions as they are made, and unnecessary delays affect not only applicants but all interested in the industries to which the inventions relate" (p. 825).

Substantially from the moment of his filing, the French public may know the pretensions of the patentee. This is just to both. In either country the inventor gains nothing, honestly, by entering the office prior to producing an operative improvement. The sooner this disclosed the better for him, for his patent, and for the public.

Is the French system criticised because several patents are thereunder issuable to several applicants for the same alleged invention? What of it? One only can be the original and first inventor and his the only valid patent. He may directly attack his rival's, or they his, at any time. In any event, the question of priority, like every other affecting validity, is tried at the outset, and usually settled once for all, by a Tribunal of original jurisdiction whose decision is not as here open to contravention by another of like jurisdiction.

Powerful opposition must be expected should Congress consider substitution of the French for our present system, but it is safe to predict that this will not come from the people, nor from a majority of those striving independently, to make patentable inventions.

Those who see their own profit in adhering to our present system, are likely to urge against the French, Great Britain's recent abandonment of one resembling the latter, to substitute therefor one more like our own, at least to the extent of permitting Examiners to judicially determine patentability in view of the prior art.

It remains to be seen how the British public and inventors will relish this change after its results are worked out fully, nor are we yet acquainted with all the hidden motives and influences which prompted it.

Germany likewise practices our present system to the extent of conferring on Examiners judicial power to grant, or reject, applications for patents, but the spirit, traditions and power of the

German people have differed greatly from ours, and many Americans, notwithstanding admiration for much in the German Patent Office, entertain definite views respecting their rejections thereby.

I am, moreover, uninformed, at this moment, regarding the compensation paid to British, or German, Examiners, but it is safe to infer from other branches of their public service, that the salaries suffice to at least render their posts permanently desirable.

In this country, however, it seems as yet impossible to induce Congress to divert from so-called " Public Improvements," the comparatively modest sums required to enable public servants, entrusted with duties on whose proper performance depends national stability, to live, or rear their families, in befitting style.

The Patent Office has already turned into the U. S. treasury over $7,029,004 net profit; it still continues to return a surplus—$30,776 during the last fiscal year.

Considering his responsibilities every Examiner entrusted with judicial functions should receive no less than the least paid Federal Judge, and even that is too little.

But this would far from remove the defects of the " system " referred to.

However, in view of Congress' persistent opposition to increasing judicial salaries, my hearers will, I think, agree that this remedy is well nigh hopeless.

It will, of course, be understood that the suggested change to the French system, while stripping the Patent Office of its present *judicial* functions, need in no other respect interfere with its present organization and emoluments.

It is suggested that, as an improvement on that system, the present force of Examiners be retained if only to search, more thoroughly than now possible, the prior art, and to append to each patent, as a guide to the Courts, and to patentees and investors, a full statement of all prior publications deemed to interfere with, or bear upon the novelty and patentability of the alleged improvement disclosed by the applicant.

Such work would be more adequately compensated by present salaries, and would afford valuable data for determining validity in advance of litigation.

The present fees payable to our government for the patent, $35, should be continued. To these might well be added, as in France, an annual tax to weed out worthless patents, and provide

funds for the sorely needed increase in salaries of Federal Judges, whose work might be increased by the change; also for compensation of independent, technically expert, witnesses to be summonable, *by the Judge*, to his assistance, in difficult cases (189 F. R., 95, 115).

To sum up, it is believed that the French system, if substituted in substance for our own, would result in:

1. Avoidance of mistake or injustice in allowing, or rejecting, patents;

2. Diminution of uncertainties, errors, oppressions, and frauds now due to patents;

3. Increased protection of truly meritorious, and corresponding exposure of unworthy, inventions and patents;

4. Ultimate economy, and a surer path, for inventors seeking patent protection.

In conclusion, there is but time for a word, respecting another defect of our " system " namely, the existing mode of trial of patent causes in our Courts. This, also, has, at last, awakened salutary criticism. But the delays, the expense to suitors, the inadequate control by the Court, of such proceedings, resulting in records comprising " mountains of costly nonsense " asserted to " give to moneyed might the means of abundantly wearying out the right," are likely, largely and soon, to become things of the past.

A drastic revision of the existing " Equity Rules " is now expected from the Supreme Court of the United States, which is, fortunately, empowered to dispose of this subject with little, or no, Legislative assistance. This revision, it is believed, will so accelerate, simplify, and control the trial of suits for infringement of patents as to satisfy all reasonable future requirements.

Discussion

The President:

Mr. Edmonds, on behalf of the American Institute of Chemical Engineers, I thank you for the learned address you have just made to us. I cannot dwell at length upon the several recommendations made by Mr. Edmonds. I have, *nolens volens*, been compelled to get acquainted with foreign Patent Law practice, and therefore I believe I am entitled to mention, as far as my own experience goes, that the French system, suggested as a remedy by Mr. Edmonds,

sounds to me somewhat like that remedy proposed by a man to his friend who had a sore tooth. He suggested that the sore-tooth-man should take a revolver and shoot the tooth out so as to relieve him of further trouble. (Laughter.) In this suggestion of Mr. Edmonds, I believe that "distance lends enchantment," and I doubt if Mr. Edmonds would feel the same enthusiasm for the French patent system if he were confronted with it in practice.

I have discussed the French system with many French manufacturers and patentees; the French are the first to recognize the great defects of their patent laws. The French patent system was organized more than half a century ago, and has received very few modifications. The spirit of the French system is radically different from ours: it has been mainly devised in order to levy taxes from the patentee, and it has exceedingly well succeeded in accomplishing this object. According to the French system the patentee for a period of fifteen years, a period shorter than the American period, pays about fifteen hundred francs, outside of patent attorneys' fees, as compared with $35 of the American patent fee for seventeen years. The French Government makes no searches as to novelty; it simply gives the inventor a certificate stamped with the date the patent is filed; it never examines whether the subject is new or not; you can file the same patent fifteen or twenty times over again without limit, as long as you pay your taxes. In other words, all the French Government gives you in return for your good cash is a cheap rubber stamp indicating exactly the date, hour, minute and second when the patent is filed. (Laughter.) Conditions are such that the Frenchmen themselves make fun of their patent system. A French patent only begins to receive some consideration if it is backed by the prestige of an American or a German patent.

What has been the progress of the French system? A few less important countries have adopted the French system; for instance, Spain, Portugal, Italy, and Belgium. Now if you begin to examine what the French patent system has done for the industries of those countries you have, on the one hand a list of the less important among industrial countries of Europe using the French system, and on the other hand you have countries with government examination as to novelty of patents, like Germany, the United States, and England, all countries which have become leaders in industrial progress. Furthermore, it is a very strange coincidence that several countries, which modified their patent system, have always come a

little nearer to the American system, or the German system of preliminary examination as to novelty. The latest modification of the patent system in England was very much in accord with the American system, and a further deviation from the French system. So that, after all, since the French patent system has existed, we have seen no changes in the patent laws of any country towards the French system, but we have seen some of the countries which have tried the French system making modifications towards the American or the German system.

There is an unfortunate condition of affairs in our patent system, which is not due to the fundamental patent laws themselves, but to the absurd way in which patent cases are tried in our courts, which puts a premium on delays and gives an enormous advantage to anyone who cannot afford to raise the money to pay for those delays. It is very easy for a large corporation or a wealthy litigant to take advantage of all the complications and delays which the law permits him to introduce, and which puts the poorer inventor with limited resources at an inexpressible disadvantage. I shall go further and state that if anyone asks me whether he should take out a patent in the United States, my answer is: "Have you plenty of money for defending your rights if you obtain a patent? If you have not, do not take out patents."

In order to remedy this intolerable situation, it is not necessary, as many think, to abolish or entirely reform our patent system. In fact, very few reforms are necessary. The abuses became serious only since the Supreme Court practically stopped its intervention in patent litigation, and thus deprived patent litigation of the prestige of a final court of appeals and of its influence in maintaining proper rules of practice and procedure. Give us a court of patent appeals which will render final decisions by which we can abide, instead of the absurd condition of affairs where one circuit court of appeals can upset the decision of another. Give us a court of patent appeals which shall formulate and maintain common-sense rules of practice and procedure, and thus stop the abominable practice of taking unrestricted testimony without a presiding judge. This will at once eliminate all testimony which has nothing to do with the case except that it is entered as a trick to indefinitely prolong litigation and to pad the records so as to drag on the case and defer judgment with the object of saddling your poorer opponent with ever-increasing expenses until he staggers under the load

and is ready to give up the fight, if in the meantime the term for which the patent has been granted has not come to an end. Let testimony be taken in open court as it is done in Germany, in England and in other countries, where cases are tried and settled at relatively small expense and in a short time, instead of taking many, many years, as happens here. In Germany and in England, patent infringements are treated just like any other violation of property rights; with the same severity as if somebody had stolen or damaged another man's property.

I am told that we have some good rules of practice formulated long ago by the Supreme Court of the United States, but since the Supreme Court ceased to function as a Court of Appeals for patent cases, the lawyers and experts, for reasons of their own, agreed to disregard these rules. I am even told that if these rules were honestly adhered to, the testimony of any patent suit could be ready for the court at the end of six months. The worst of all is that after spending endless amounts of money and time, and after your case has been decided in your favor, an infringer, helped by a clever lawyer, need not fear any claim for damages because it is very easy to manipulate the law so as to make it practically impossible to prove well-defined damages as stipulated by some court decisions.

I hope that Mr. Edmonds will not misconstrue my remarks. I much agree with the first part of his paper: Priority decisions are based on facts which can be verified; but decisions as to whether any invention involves much intellectual effort or not is a matter of opinion. This opinion may vary from person to person, and is entirely subjective to the condition of mind of the examiner at the time when he renders the opinion. This explains the immense divergencies of opinion as to the relative importance of certain inventions.

I only wanted to put the soft pedal on the enthusiasm of Mr. Edmonds for the French Patent system. (Laughter and applause.)

Mr. Walter F. Rogers:

Mr. President, if my friend, Mr. Edmonds, had not smiled when he said those strong words at the beginning of his paper, we should have thought that he really meant them.

Our laws need only to be read, I think, to be appreciated. They are the result of not only 120 years of our practice, but, in fact, of 250 years of the experience of English-speaking peoples. I understand, therefore, that no serious fault can be found in the law. The

essence of the law is, of course, *the examination*. I see here to-day five graduates of the Patent Office, and those five men have held, I think, every position, certainly have had every possible experience, in the Patent Office. We know the crimes we committed when we were there, and we appreciate fully the crimes that can be committed by those who are left behind, which are of course, greater than any crimes we committed. (Laughter.)

Now, Mr. President, I am standing here to answer in this offhand manner a carefully prepared paper, because I feel bound to speak for the general patent bar in one respect. The Patent Law Association of Washington represents, as nearly as possible, the chosen patent bar of the United States. We have over 500 correspondents. We are in close touch, and have been in close touch with that patent bar for some twelve years past. We know, I think, the sentiments of that patent bar, and I can assure you that although this matter has come up from time to time, there never, hitherto, has been left a grease-spot of any proposition to abandon this working system of examination; a system that requires nothing but facilities to make it the greatest engine of industrial information in the world. To abolish a system that presents splendid opportunities for great work, in order to take up some "revenue" system which has not worked well, and which has been abandoned after careful consideration by other progressive countries, is not a forward step.

Mr. Edmonds referred, for example, to the Selden patent. He spoke in appropriate metaphor about that patent having wound its coils around a rather healthy opponent and then finding it necessary to let go. Now suppose that patent with its original claims had been granted at the beginning of the industry, I think it quite probable that it might have seriously crippled that industry.

Mr. Edmonds spoke of 57 per cent of the applications being granted and 43 per cent being refused. We should have in that 43 per cent, then, the very essence of error, and, I should say, a great majority of worthless patents placed about the country; and no matter what you may say, the country believes that somewhere or somehow the Government is back of anything bearing the Government stamp. People to-day believe that a trade-mark is of some importance beyond the mere evidence of a claim to a right, and they would believe the same sort of thing if this 43 per cent of patents were granted, that are now stopped by the Patent Office. The

applicant has a right to go to the Examiners-in-Chief, and in addition, to the Commissioner and then to the Court of Appeals, and then to a court of equity, so that mistakes may be corrected.

I am very much reminded, when this matter comes up, of the minstrel story at the time of a Republican landslide (that was some years ago) (laughter) when a man turned to the man beside him and said "You voted the Democratic ticket." Then the conversation ran—"I didn't." "You did." "I didn't." "Well," said the accuser, "somebody did." (Laughter.)

Now, Mr. President and gentlemen, with reference to searches, you know, confidentially, I do not believe my good friend here, Mr. Kenyon, of New York, nor, on the other hand, my good friend, Mr. Edmonds, of New York, makes those searches himself. I do not believe if either had to determine, at great expense to himself, and to his client, the validity of a patent he would make the search. I do not know whether he would pay a man $1500 or $2000 a year, to make those searches, but I think the chances are strong that he would have to have a good many people at substantially the same salaries as the Assistant Examiners who would make the search. So that, when you come to the personnel of the men who have to make the searches at the low salaries, we are all agreed that you cannot undertake to do this particular work any better than Uncle Sam does or can do. Men come into the Patent Office as a result of examinations. The men coming in there to-day are young men. The rank and file are all right. It is not the rank and file who are at fault but some of the too numerous chiefs—though there are brilliant exceptions present in this room. As a rule, I think, the shortcomings are the result of having 43 divisions in the Patent Office. You cannot get 43 (and, as it will soon be, 50) chiefs of divisions who can take care of so many men, especially when these men are separated and scattered through various arts, and you cannot expect to have that first and thorough search which is the right of the inventor on filing his application. But that is a reason for modifying the administration and for having everything there, every facility that ought to be there; for having the scheme carried through carefully and well.

When you compare the judges—confidentially I have known judges to be wrong; I do not know, but I have very excellent reason for believing that Mr. Edmonds has known judges to be wrong.

Mr. Edmonds:

No, I do not say that. (Laughter.)

Mr. Rogers:

Well, we are all behind the court. All that we lawyers can do when the judge is wrong is to go behind the door and talk about him. And, after all, he is put there *to decide questions*. I heard a judge say once, "I am not here to do justice; I am here to decide questions." And there is some reason in that. While there are lots of incompetents in the Patent Office, there are also many at the bar, and—well, I will not go any higher than that.

When I went into the Patent Office (so many years ago that my hair ought to be gray) I was assigned to the Agricultural Division and my specialty was that interesting old class "Trees, Plants and Flowers." An application was filed for a "hot-bed" and I having "hot houses" examined it. The applicant showed a big steel frame with a red-hot rail on top of the frame. I asked him to enclose his steel frame with glass and asked him to explain why he used a red-hot rail to heat it. My letter passed the Examiner and the attorney in his reply did not seem to enter any serious protest. Possibly he was too much overcome. My instinct told me that something was wrong. I went to the Metal Working Division and asked the Examiner in charge if he had anything known as "hot-beds." He replied, "Oh! yes. They are beds on which to cool the red-hot rails when they come from the rolling mill." Now that was a good joke on someone and it might have been made the basis for a criticism of the Patent Office, but it did not disintegrate the system and certainly was no reason for changing the method of examination.

As an offset to the just complaints which we frequently hear respecting ridiculous instances of examination, I could point to thousands of instances of excellent work done by the examining corps of the Patent Office.

There are thousands of instances, too, of excellent work done by the bar, and yet, on the other hand, we unfortunately have on our rolls men who rely almost entirely upon the Examiners for guidance.

Reference has been made to a recent case of bribery in the Patent Office—the one case, so far as is known, in a century.

On the other hand, we, unfortunately, know of a number of men

who have been disbarred from practice, one for stealing stamps from the Patent Office. I do not think, however, that such an instance is more than a fly in the ointment, and hardly a blot on the 'scutcheon. I do not propose to let my hurt continue because there is a fly in the ointment, nor do I propose to surrender my claims to ancestry even if there be some place a blot on the 'scutcheon.

I know of few instances in which any harm has been done. When, in referring to the personnel of the Patent Office, it is said that one man in the corps has done something that is illegal, the sufficient answer to that is that he is now in jail. When I was in the Patent Office I recall that an applicant tried to bribe an Examiner—and he went to jail for eighteen months.

I do not believe you can pick out any number of men in any line of business who are attending to their business more faithfully. Nor are the difficulties in the law; they are in the lack of facilities for the proper administration of the law.

Some years ago when I was in the Patent Office, a fine old man came down from the North. He said he was a switch-tender. He was turned over to me to help him out. We did not do that often in the Patent Office, but in some cases we really had to do it. The old fellow had five inventions, I think it was. One was a frame for a scotch-cap; one was ear-mufflers; one was blinders for the eye; two, so that he could throw one back; one was a frog for an electric switch; and one was a raincoat with gutters on it so that the water would not run down your hand. I found everything for him except the blinders. The old man then stood up and said, "Mr. Rogers, I did not care when you found that electric switch, and that cap, and those other things, but I could have cried when you found that raincoat with them gutters on it." And he did cry. The tears rolled down his face as he stood there.

He belonged to one class of inventors who are better stopped at the Patent Office. Suppose he had received those five patents! He would have been deceived and encouraged to pursue a hopeless road to an imaginary fortune.

He came back to my office some years afterwards and said, "Well, I've got it this time. I have a hoop with bells inside and when you roll it all the bells jingle." I said: "What train do you want to take back home?" He said: "Why, what do you mean?" I explained by taking him to the office and showing him another device almost identical with the one which he had invented.

That is the work the Patent Office also does and must continue to do if it is not done before the Patent Office is reached. There are thousands of cases where the Patent Office prevents the inventor from getting into the wrong channel, and guides him in the way in which he ought to go.

Just one more moment. A man came into my office once and said impressively—"Are we alone?" I said, "The typewriter girl is in the next room, but there is the keyhole there; you can hang up your hat over it." "Well," he said, "I have a wealthy friend out in Chicago, where I am judge of one of the courts, and he has a great invention for a typewriter; when you press your foot it makes the space bar move." I said, "Suppose we go over to the Patent Office." I presumed upon my acquaintance with the Assistant Examiner, and leaving the judge out in the corridor, I went into the room and said, "Mr. Ramsay, where is the box with the things that you pull and push to work the space bar." Mr. Ramsay replied, "In those three red boxes up there." After the judge and I had looked at the interesting pictures showing all sorts of gymnastic exercises for operating the space bar, the judge suddenly said, "Where is the nearest telegraph place?" I went across the street with him to the telegraph office and this is what he wired to his friend in Chicago: "Jig's up. Woods full of them." (Laughter.)

Now, Mr. President, that is what the Patent Office does—not always—but generally. We do not all of us do it, but the most of us try to do it. We cannot, however, reach all cases in our own offices. We must rely largely upon assistance, and that is true of all my friends here about me.

It is because of that class of old men, and younger men, such as I have mentioned previously, that the Patent Office does this work of examination, and it is in the interest of the public that it should be done and done thoroughly as a result of an endeavor to ascertain the scope of the invention.

It is the purpose of the claim in a patent to "particularly point out and distinctly claim the part, improvement, or combination" which is the new invention. Whatever the occasional shortcomings, no other patents in the world so precisely indicate just what the patentee claims to have invented as do the United States patents.

The progress in this country of the great arts can be fairly traced by a mere reading of the claims of the patents in those arts.

It is, of course, the examination that makes this possible.

I have been in close touch for many years with one division especially, where they do excellent work, and when I make a search in that art it costs my client far under the sum which would be required but for the work which is done in that division. Now, if we insist that this work shall be made more generally helpful to the public, if we insist that the money we have paid in shall be expended for facilities, we shall have the greatest patent system that can be devised. In short, I can see no possible reason for abolishing this system, which has worked in the main so satisfactorily for a century, merely to take up a system hitherto untried in this country.

The PRESIDENT:

What Mr. Rogers says is true. Personally, and in accord with several of my friends, I find that criticisms and rejections from examiners of the Patent Office, have frequently been very valuable to me; they have often helped me much to put my cases in proper form. In fact, so much am I convinced of this that I certainly would have been willing to pay several times the cost of the Government fee for the benefit of these criticisms and the search as to novelty. I will go one step further and say that I have found it decidedly advantageous to take out patents in Germany. Not so much with the idea of selling my German patents, but more specially in order to receive, at a trifling cost, expert advice on the patentability of my inventions from the German patent examiners, and thus confirm the decisions of the American patent examiners.

The time, gentlemen, is drawing rather close, but any of you can submit further written discussion to be entered in the records. Nevertheless, if Mr. Edmonds desires to add any answer to the remarks which were made here in relation to his paper, he is invited to present them now.

Mr. EDMONDS:

I have only a word to say in reply. My learned brother Rogers did not understand me, perhaps. I am not championing particularly this introduction of the French system. I am groping for something which will relieve the defects which even he mentions. I particularly stated, in my address, that the present organization and emoluments of our Patent Office should not be changed, except in the one particular of either restraining, or abolishing, the judicial function which is now entrusted to 377 men; and my own understanding and that

of others is that the Examiner's turning down of those hothouses, etc., patents indicates the possibilities of injustice through the turning down of other, very different, patents which ought to be allowed. And, vice versa, notwithstanding all that has been said, the allowing a multitude of patents to issue, which are absolutely worthless and which constitute possibilities for fraud, is a condition which ought not to exist.

Now I make no special advocacy for the French system; it is only a suggestion. But I do say that if the Patent Office did only just what Mr. Rogers has been so well doing, namely make a thorough search on every application, and reported whatever anticipations found, many inventors would go no further, and that would *properly* and effectively end the matter. My main contention is that the *judicial functions* which the Examiners are now exercising, in granting or stifling patents, ought to be restrained, or, better, wholly abolished. And I do take issue with my brother Rogers' suggestion that, because *errare est humanum*, our Federal Courts are, in their judicial determinations of the respective rights of inventors and the public, quite as likely to err as are the 377 Examiners of the Patent Office. The reasons given in my address for condemning the existing double adjudication to determine validity, and for preferring a single public trial by a permanent judge to a secret *ex parte* one by the changing staff of a Departmental Bureau, I have yet to hear satisfactorily answered.

THE UNITED STATES PATENT SYSTEM

By ROBERT N. KENYON, Esq., of the New York Bar

Read at the Washington Meeting, Dec. 22, 1911

It will be generally conceded, I believe, that the framers of our Constitution showed a far-sighted wisdom in providing in that instrument that Congress should have power to grant to inventors for a limited time an exclusive right to their inventions, and that the Patent System which has been created under that provision has contributed in large measure, and probably more than any other single factor, to the marvelous mechanical and industrial progress that has been made in this country in the last century and notably in the last forty years. Whatever defects may be found in our Patent Laws, and however severe the criticism of them may be at the present time, we should not forget that these laws have as a net result conferred great benefits upon the people of this country. The American is endowed with the inventive talent in a high degree and this talent has been tremendously stimulated by the rewards which the Patent Laws have offered. In the field of invention the United States leads the world, and no sufficient explanation of this superiority can be found except in the more complete and efficient development of its Patent System and the greater liberality which it has shown to its inventors. No more striking proof of this can be adduced than the fact that the other nations of the world which are the most progressive have, in recent years, been changing their systems to make them conform more nearly to our own. A great army of inventors has been developed in this country who are working constantly to improve every human contrivance that man employs in his daily work and life. Many of these men have come from the humbler and poorer classes, and the pecuniary rewards which their inventive work has secured under the law have far exceeded anything they would have won by other means. When a system has contributed so largely to the public good, it is the part of wisdom to proceed cautiously in modifying it.

Yet it must be admitted that there are serious defects in our Patent Laws and their administration, defects which have become more apparent and have been more seriously felt in recent years. The inventor complains of the law's delay in granting and enforcing his rights, of the intricacy and vexation of the proceedings in the Patent Office, and the Courts, of the heavy burden of expense involved in such proceedings, of the undue advantage enjoyed by the rich and powerful corporation, and of the inadequate recoveries granted by the Courts even after patents have been sustained and infringement decreed. On the side of the public it is claimed that many patents have been granted that should not have been granted, and that an unjust burden of litigation has thus been thrown upon many innocent manufacturers and dealers, tending to hamper and check legitimate industry. It is also charged that patents have been used as an instrument in the hands of unscrupulous parties and corporations to create or promote unlawful monopolies, extending to unpatented articles. The general sentiment against monopolies has become so strong and aggressive that it has extended even to our Patent System, and has created a feeling of hostility toward it which is not deserved, but which is threatening dangerous innovations.

In the present state of the public mind, and in view of the conditions I have referred to, it seems certain that the Patent Laws must and will be amended within the near future. It is my purpose to point out some changes in the law and the practice which I believe would be beneficial. I shall consider first the subject of Court Procedure.

Procedure in the Courts

It has been said that when an inventor secures a United States Patent, he is getting nothing more than a license to bring suit. In a sense that is true. The Government does not guarantee the validity of a patent. It does not assume the task or the responsibility of preventing infringements. When an infringement occurs, the inventor or his assignee must bring a suit, and in this suit all questions of novelty, and patentability, and the like, are open, and must be considered by the Court, if presented by the defense.

The inventor may bring a suit in equity or an action at law, as he sees fit, but as nearly all of such suits are on the equity side of

the Court, I shall confine my attention to a discussion of the procedure in such equity cases.

An equity suit is begun by the filing of a Bill of Complaint in which the complainant sets out his case. The defendant has about two months thereafter in which to appear and answer or otherwise plead. The complainant then has from one to two months in which to reply to the answer or take other suitable action thereon. The result of this procedure in ordinary cases is to give to the parties about three or four months after the commencement of the suit for the completion of the pleadings and the settlement of the issues, and the preparation of their proofs. This is not an unreasonable amount of time. The chief defenses in a patent suit are generally based upon the prior art, consisting of prior patents and publications, United States and foreign, and prior uses in this country. A thorough investigation of such defenses ordinarily involves a large amount of work, and the time allowed a defendant for this purpose is none too great. Indeed in many cases a longer period of time may be required, and the Court is empowered to grant such additional time or to allow a subsequent amendment of the answer.

When the pleadings have been filed, the next step is the taking of the testimony. Section 862 of the U. S. Revised Statutes provides that the mode of proof in equity causes shall be according to rules prescribed by the Supreme Court except as otherwise specially provided in the Statutes. Rule 67 of the Equity Rules formulated by the Supreme Court provides amongst other things that the testimony in equity causes shall be taken before one of the Examiners of the court, or before an Examiner to be specially appointed. This Rule was not drawn with special reference to patent cases but applies to all suits in equity; but nearly all patent litigation, being brought in equity, is governed by its provisions. When the testimony is finished, each party prints his own evidence, or pays the clerk of the court for printing it, and the case is then argued before a judge upon this printed record.

This method of taking the evidence is open to serious criticism, and is the feature of the present practice which is most generally condemned.

It is a slow and tedious method of presenting proofs especially in patent causes. It is an unfortunate fact that, under this practice, patent cases generally drag along for two or three years or even longer, after the filing of the bill, before they are ready for argument. This

often amounts to a denial of justice. During all this time, if no preliminary injunction has been granted (and such injunctions are rarely secured) the infringement is continuing, the complainant's business is being injured, perhaps irreparably, and the defendent is reaping profits which, by reason of the technicality of the law of recoveries, he is seldom decreed to pay over to the complainant. In the famous Selden case, the first suit was brought in 1900. This was settled in 1903. A second suit was brought in 1903 against the Ford Motor Company. The taking of testimony in this case lasted for the extraordinary period of about five years, and the case was not argued until May, 1909. Meanwhile the complainant was being unjustly deprived of its monopoly, if the patent were valid and broad in scope, as the lower court held it to be. The swarm of infringers were enjoying through all these years an illegal profit, if the patent were in fact valid and broad. The manufacturer who did not wish to infringe upon a legal monopoly was left in the dark for years; he did not know what his rights were. If he manufactured he did so at his peril. Clearly it was to the interest of the complainant company, if its patent was valid and broad, to have an early adjudication of its rights; and, if the patent was invalid or narrow, as it was afterwards held to be by the Court of Appeals, it was clearly to the interest of the public that a prompt decision should remove this cloud upon their business. But there was a great volume of testimony to be taken, and under the present method almost five years were consumed in taking it. If the case had been tried in open court, it would probably have been disposed of in a small fraction of this time.

The present practice also opens the door to great abuses in the offering of testimony that is irrelevant or immaterial or incompetent. Rule 67 provides that the examiner shall not have power to decide on the competency, materiality, or relevancy of the questions. He is a mere transcribing officer. When a question is asked he must write it down, no matter what it may be, and the witness must answer it. It may be on a subject not having the slightest bearing on the issues of the case, or the facts testified to by the witness on his direct examination; it may be foolish, or impertinent, or insulting, or even indecent, but the witness must answer it, and the answer be put down, unless the witness claims that an answer might incriminate or degrade him, or takes the matter in his own hands, and either of his own will, or under the advice of counsel (which some courts have

held that counsel has no right to give), declares in righteous anger that he will not answer the question, the Supreme Court of the United States to the contrary notwithstanding, unless the court before whose examiner he is testifying enters a special order commanding him to do so. Where a witness flies in the face of the rule, though he may be more than justified in his position, his whole deposition may nevertheless be struck from the record. The result is, particularly in patent cases, that the record is often inexcusably expanded. Pages upon pages of testimony are introduced which would never be admitted and probably never offered were the case being tried in open court. In the Selden case the record, when printed, comprised more than a dozen volumes, each of large size. In open court this would have been reduced to a small fraction of that size. And what is true of this case is true of most patent cases in a considerable degree.

It results from all this that patent litigation is exceedingly expensive. The cost is prohibitive for the man of small means. The examiner's fees are regulated by statute at so much per session and a certain amount per folio for the original and an additional charge for each copy. These fees are taxable against the defeated party. With records unnecessarily expanded, the examiner's bills often amount to thousands of dollars, and when counsel's fees, at so much per day, are added, the bill is one that only the rich man or the rich corporation can afford to pay. When the testimony is finished, it must be printed at an expense of nearly a dollar a page, and this adds another large item to the cost. It is no wonder that many inventors have preferred to sell their valuable inventions to a wealthy corporation for a wholly inadequate price rather than to assume the great financial burden of a patent suit.

How can these defects in the administration of the Patent Law be remedied? It seems clear that the first thing that ought to be done is to change the procedure so as to provide that the testimony in patent causes, or as much of it as possible, shall be taken in open court before the judge who is to decide the case, just as, in actions at law, the testimony is taken before the jury. This would greatly expedite the trial of such suits, and would go far toward preventing the present vexatious and burdensome delays. The record would be confined to proper evidence, for the Court would rule upon the questions as they are asked, and would exclude testimony that is improper under the established rules of evidence. The judge would see the witnesses himself, and would thus be better able to

determine their honesty and credibility, and the weight which should be given to their testimony. He would understand the case as it progressed, and would have a much better grasp of the difficult mechanical and scientific questions involved than he could possibly obtain from the mere reading of printed depositions. Moreover, he would have the great advantage of being able to ask questions himself, whenever the testimony of a witness was obscure or doubtful in meaning. This would be particularly helpful in connection with the examination of experts. It is obvious that if the Court could hear an expert testify and could call upon him to explain any doubtful point, when the doubt arose, or to supply any omission that might occur in his evidence, or to explain the meaning of terms in the art, the Court would certainly obtain a better knowledge of the subject-matter and the issues involved than is possible under the present practice.

And the mental attitude of the expert himself would be different. At present the giving of expert depositions in patent suits is too much like a war of words or wits between the witness and cross-examining counsel in which the witness is seeking to present and marshal the facts favorable to his own side of the case and to belittle or pass lightly over the facts that are unfavorable. The present practice tends to develop the habit of evading and of giving irresponsive and argumentative answers. If an expert testified in open court, his testimony would certainly be more direct and frank, for the judge would be there to insist upon fair and responsive answers, and the expert would know that the weight to be attached to his evidence would depend largely upon the manner in which he testified. Expert evidence would be greatly shortened and clarified, and the Court would have less difficulty in determining whom to believe. In such an examination of witnesses in open court, cross-examination would be limited within a reasonable scope, thus causing a material saving in time, labor, and expense.

This procedure is followed to-day in the trial of patent causes in England. In a letter which I have recently received from one of the best known firms of chartered patent agents in London, they say, in speaking of this subject:

" The practice in the English courts is eminently satisfactory; there is a remarkable absence of red tape, the proceedings are expeditious and the courts take a broad view, and give their judgments on matters of real substance."

In commenting on the English practice of examining experts in open court, they say:

"The examination of experts is not long drawn out in the majority of cases, for the questions and answers are short and snappy rather than diffuse and calculated. As the whole evidence is taken in the open Court the proceeding resolves itself into a dialogue between counsel and experts during which the judge is enabled to grasp all the essential facts without putting more than an occasional question of his own."

A plan has been suggested for the improvement of our present procedure which commends itself to my judgment, and which resembles in some respects the present chancery practice in the High Court of Justice in England. It is substantially as follows: When the pleadings have been filed the complainant shall within a certain time give notice to the defendant that he will apply to the court for certain directions as to the taking of testimony and other matters, specifying what directions he will ask for. The defendant shall have a certain time thereafter within which to serve upon the complainant a notice of the directions which the defendant will ask the Court to make on his behalf. The parties shall, at the appointed time, appear before a judge of the Court to have these directions settled and ordered. Complainant's counsel shall state to the Court briefly the nature of his case, and in general what testimony he desires to take, and shall ask for any special orders he may desire for commissions, or examination of witnesses before trial or *de bene esse*, or production of documents, or inspection of property or for other purposes. Defendant's counsel shall then make a similar statement in relation to the defense, and ask for such special orders as he may desire. The Court shall then make suitable directions and orders, on all these matters, determining amongst other things what testimony, if any, shall be taken out of court and how and by whom it shall be taken, and allotting times for that purpose. It shall set a time for the trial at which the parties shall present their proofs in open court, except such evidence as may have been ordered to be taken before trial. The Court should have power in its discretion to adjourn the trial for a short time after complainant's opening case has been presented to allow the defendant to further prepare his case and this practice should be followed in patent causes whenever the nature of the subject-matter is so difficult that in the judgment of the Court defendant is

entitled to such additional time to prevent surprise or injustice, for it is sometimes true that the defendant is not advised as to the complainant's theories until the complainant has presented his opening proofs, and in such cases defendant should be given some time to consider these theories with his expert. Thereafter the trial should be resumed, and defendant required to produce his testimony in open court except as otherwise previously ordered. Then a further short adjournment might be taken to permit the complainant to consider defendant's theories and to prepare to meet them, if the Court considered that the complainant was fairly entitled to such additional time. Then the trial should be resumed and the complainant's rebuttal evidence taken in open court except as otherwise ordered. The case should then be argued by counsel, after which a reasonable time could be allowed for the filing of briefs. I believe that this procedure, thus merely outlined, would bring patent litigation within reasonable limits as to time, labor, and expense, and would promote justice both to the inventor and the public.

There is a certain kind of testimony quite common in patent causes which has to be taken before trial. I refer to testimony particularly in support of prior uses given by witnesses who live so far from the place of trial that they are beyond the reach of the subpœna. The statutes provide that such testimony can be taken before a notary or other proper officer in the form of depositions *de bene esse*. This practice must, of course, be preserved. It would be advisable, also, to amend Rule 67 so as to give the Court in one district power to appoint special examiners to take testimony in any other district in the country.

All these matters should be definitely settled when the parties come before the Court for directions as above suggested. If further directions were needed at any time during the progress of the case, the parties could be brought before the Court on suitable notice by either side and application made for such further order. All motions and applications in a particular case should be made to the same judge and the case should be tried by him. This judge would quickly become familiar with the nature of the suit and would be in close touch with it, and could thus see that no undue delay was permitted.

One cause of error in the trial of patent suits grows out of the fact that these suits involve mechanical, chemical, or other scientific

questions, which are often exceedingly technical and subtle, and yet these questions have to be determined by judges most of whom, though learned in the law, have had no mechanical or scientific training. Questions in mechanics and chemistry which would be puzzling to a trained engineer or chemist, must be decided by a judge who has never had any education or training in those subjects. He is compelled to rely upon the evidence of the experts for guidance. But the very terms in which the experts speak may be almost as strange to him as the words of an unknown language. We would not expect a chemical engineer, no matter how distinguished he might be in his calling, to satisfactorily decide difficult questions of law. Yet we do expect lawyers who sit upon the bench as judges to pass upon equally difficult questions of chemistry. It is not surprising that the courts now and then fall into serious scientific error. It is surprising that such errors do not occur more frequently.

In a recent decision in the case of *Parke-Davis Co. vs. Mulford Co.*, 189 Fed. Rep. 115, Judge Hand says:

"I cannot stop without calling attention to the extraordinary condition of the law which makes it possible for a man without any knowledge of even the rudiments of chemistry to pass upon such questions as these. The inordinate expense of time is the least of the resulting evils, for only a trained chemist is really capable of passing upon such facts, e.g., in this case the chemical character of Von Furth's so-called 'zinc compound,' or the presence of inactive organic substances. In Germany, where the national spirit eagerly seeks for all the assistance it can get from the whole range of human knowledge, they do quite differently. The court summons technical judges to whom technical questions are submitted and who can intelligently pass upon the issues without blindly groping among testimony upon matters wholly out of their ken. How long we shall continue to blunder along without the aid of unpartisan and authoritative scientific assistance in the administration of justice, no one knows; but all fair persons not conventionalized by provincial legal habits of mind ought, I should think, to unite to effect some such advance."

It has been suggested that one remedy for this evil would be to empower the Court to call upon some impartial expert to advise with it on the scientific side of the case. This is now the practice in Germany. There the Court usually summons some expert of its own choice to instruct it upon the mechanical and scientific

issues. It may also call upon the Patent Office for an opinion. Either side may challenge the expert on the ground that he is prejudiced or has already given an opinion upon the questions at issue.

It must be admitted, however, that there are serious objections to such a plan. It would be easy to secure an honest expert but it would be difficult to find a truly impartial one. The more learned an expert is the more likely he is to have some previous knowledge of the very questions in issue, and to have formed a previous judgment more or less complete upon those issues. No matter how conscientious he is, he is likely to approach the subject with some preliminary bias, which may result in great injustice. Such a plan also leads to a division of responsibility between the judge and the expert.

It would seem wise therefore to go slowly in this matter, and to try first the procedure suggested above of having each side examine its expert in open court where the judge can hear the testimony, and can himself ask questions of the witness. Experience may show that a judge can in this way secure as good an understanding of the subject involved as he could reasonably hope to do from an expert appointed or called in by himself. At all events it is wise to take one step at a time in the case of such a radical innovation.

Another feature of the present system which should certainly be reformed is the practice in the matter of appeals. Prior to 1891 an appeal from a final degree in a patent cause could be taken directly to the Supreme Court of the United States. When that Court rendered its decision, all the issues involved in the case were finally disposed of for the whole country. The decision was binding upon the Circuit Courts all over the land. If the patent was sustained, the owner of the patent could rest secure in the enjoyment of his property, unless some wholly new defense were presented in a subsequent suit; and in such case practically all that the complainant had to do in the later suit was to meet the new defense. The principles and rulings announced in the first decision became the law of the subsequent litigation.

In 1891 the Supreme Court became so burdened with work that it became necessary to find some relief, and for that purpose an appellate court was provided in each of the nine circuits, called the United States Circuit Court of Appeals for that circuit. Appeals lay from the Circuit Court to this new Circuit Court of Appeals

in nearly all cases, and in many classes of cases, including patent suits, the decision of the Circuit Court of Appeals was final, there being no appeal therefrom to the Supreme Court. This has given rise to an extraordinary condition of things in patent litigation. The exclusive rights granted by a United States patent are coextensive with the country itself. If a patent is valid, it is certainly valid as to the entire country, and *vice veras*. But under the present system, with its nine courts of last resort in the nine different circuits, a patent may be held good in one circuit and bad in another upon the very same testimony, or may be differently construed.

For example, in the case of *Westinghouse Electric and Mfg. Co. vs. Catskill Illuminating and Power Co.*, 121 Fed. Rep. 831, certain Tesla patents were held invalid by the Court of Appeals for the Second Circuit; in the later case of the same complainant against the Stanley Instrument Co., 133 Fed. Rep. 168, the same patents were held valid by the Court of Appeals for the First Circuit on substantially the same evidence. Again in *Eldred vs. Kessler*, 106 Fed. Rep. 509, the patent in suit was narrowly construed by the Court of Appeals for the Seventh Circuit, and the defendant's device held not to infringe. Thereafter in *Eldred vs. Kirkland*, 130 Fed. Rep. 342, the same patent was more broadly construed by the Court of Appeals for the Second Circuit, and the defendant's device held to infringe, although it was substantially the same as the defendant's device in the earlier case.

It results from this that litigation upon a patent may be continued interminably and that it is limited only by the financial resources of the parties. When a patent has been sustained by the Court of Appeals in one circuit, the monopoly has been secured in that circuit, but not in the other eight. If infringement is committed in another circuit, the owner of the patent must sue again in the second circuit, and must fight the case all over again and as thoroughly as he fought the first one. While he is likely to prevail in the lower court, because that court presumably will follow the decision of the Court of Appeals in the first case as a matter of comity, he is not sure of prevailing in the higher court, for the new Court of Appeals in the second case is not bound by the decision of the appellate court in the first case, and may reach a different conclusion, and hold the patent invalid. On the other hand the patent may be held invalid by the first Court of Appeals, and the public in other circuits may thereby be induced to manufacture,

use and sell the article, supposing it to be public property. The owner of the patent could then sue in another circuit, and the Court of Appeals there might hold the patent to be valid. Thus a patent might be held good in four circuits and bad in five, and the result would be a hopeless confusion of rights as between the public and the owner of the patent. And years of litigation would result. This system puts an instrument of oppression in the hands of a wealthy corporation owning a patent, for it might, as a mere matter of business policy, after being beaten in one circuit, continue to sue other parties in other circuits, one after another, until the whole circle of nine had been completed, and the greater part of the public would prefer to submit rather than to incur the cost of defending. The fact that a defeated party may petition the Supreme Court to review the case, does not afford an adequate remedy, because the granting of such petitions is purely a matter of discretion, and statistics show that they are granted in very few cases.

There should be a single Court of Appeals in patent cases. A new court should be created for this purpose to sit in Washington to which all appeals should be taken in patent causes from every circuit. The decision of this court would be final upon all the issues involved, and would be binding upon all the Federal Courts throughout the country, just as the decisions of the Supreme Court were, prior to 1891. A bill to create such a court has been before Congress for some time, and has received the support of the American Bar Association, and, I believe, of a very large portion of the patent practitioners of the country. One great advantage that would result from the creation of such a court, properly constituted, would be that the law would be uniformly construed and administered in all the circuits.

It has been suggested that this appellate jurisdiction in patent causes should be conferred upon the new Court of Commerce. This in my judgment would be a mistake, first, because the judges of this court, though able and learned men, were selected for another purpose, and without any thought as to their qualifications in patent matters, and because, as I am informed, only one of the five has in fact had any experience either as a lawyer or a judge, in the practice or application of the patent law; and, secondly, because the appellate work in patent causes would be so extensive as to require the entire time and attention of the Court. Such a court would have a great task and could perform a great public

service in building up within the next ten or twenty years a body of decisions under the patent law that would be uniform and consistent, and would enable the public and the bar to know with reasonable certainty what the law is, and to shape their course of action accordingly. The vast amount of property invested in or dependent upon patents is certainly entitled to this recognition and protection, and the public interests require this as a protection against unjust monopoly and oppressive litigation.

It has been suggested that this new court should hear appeals from the highest tribunal of the Patent Office. In my opinion this would be unwise. In *ex parte* cases the Primary Examiner, if he rejects the application, does so generally upon certain prior patents and publications. He determines for himself what these prior references disclose and how they bear upon the application in question, without the aid of any expert or other testimony. He is presumably an expert himself in that particular art. Upon appeal from his decision, the higher officials of the Patent Office act upon their own unaided opinions. They are appointed by reason of their special attainments and qualifications fitting them to pass upon just such technical and scientific questions. If an appeal were then taken to the new Court of Appeals, it in like manner would have to pass upon all the technical questions involved without having any testimony of any kind to guide it or instruct it. Let us assume that it reversed the Commissioner and granted the patent, and that thereafter suit was brought upon this patent and the defendant in this suit relied upon the same prior patents and publications that had been cited in the Patent Office as establishing invalidity. The defendant would take the testimony of experts to show that these prior references disclosed the invention in question or that the patent in suit described nothing patentable over them. This testimony might throw such new light upon the situation that the lower court, coming to the consideration of the subject for the first time, might hold that the patent was invalid. But when the case reached the Court of Appeals, the defendant would find himself in a position of great disadvantage. He would be arguing his case before a court that had already decided the very same issues against him on the appeal from the Patent Office. He could urge that the prior decision was made upon an imperfect presentation of the case, upon a record that contained no evidence whatever, and that the testimony now presented for the first time

showed that the Court had been mistaken in its earlier opinion. But this would place a heavy burden upon the defendant and would be eminently unfair to him. When a court has once decided a question, no matter how imperfect the record, it is strongly inclined thereafter to follow its prior opinion. Judges are human; they do not like to reverse themselves, or to confess previous error. There would be a strong prejudice in favor of their earlier views. The tribunal in this respect would not be impartial. The defendant's case would be in a measure prejudged against him. No defendant should be compelled to try his case in an appellate tribunal that has previously been required to pass upon the same questions in an earlier proceeding where no testimony could be taken to instruct the court on the scientific questions involved. The injustice of such a procedure is apparent. And a defendant should also be permitted to set up the claims of a rival inventor and to present this question to the court of last resort without being similarly prejudiced by a prior decision of this court between the same two claimants in an interference proceeding originating in the Patent Office.

The Substantive Law of Patents

The substantive law of patents in this country, by which I mean that part of the law which defines the rights and remedies of inventors and patentees, as distinguished from the method of their enforcement, is in most respects satisfactory and indeed admirable. In its present form it is the result of many years of experience and growth and it is unquestionably the best and most satisfactory system of patent law in the world. In one respect, however, it seems to me to be lamentably deficient or ineffective, and that is in the remedy which it provides for a patentee when his patent has been sustained by the Court and a decree given against an infringer.

Section 4919 of the Revised Statutes provides that damages for the infringement of any patent may be recovered in an action at law, and that the Court may in its discretion increase the amount found by the jury as the actual damages to a sum not exceeding three times that amount.

Section 4922 provides that in a suit in equity, where a decree is rendered for the complainant, the Court may award to the complainant the damages which the complainant has suffered in addition

to the profits which the defendant has made and the damages may be trebled in the discretion of the Court.

On its face this law would seem to be sufficient, but the Courts have construed it to mean or to require that the complainant in an equity suit must show by evidence which amounts practically to a mathematical demonstration the exact part or fraction of the defendant's entire profit or the complainant's entire damage which is due to the use of the infringing device or feature, as distinguished from the part of the damage or profit which is due to other things which the defendant has done or used in connection with the infringing part or feature. This construction or application of the law has made it impossible in most cases for the complainant to obtain any recovery at all, although it was apparent that complainant had been greatly damaged and defendant greatly profited. A defendant rarely makes a device which contains nothing but the invention in question. The patented device or feature is almost always associated with unpatented parts or features, and yet the damage or the profit is single or unitary and there is no possible way of determining by a definite mathematical calculation how much of this profit or damage is due to the patented and how much to the unpatented parts.

A striking example of the impossibility and injustice of this mathematical rule is found in the decisions of the courts in relation to design patents. In the case of *Dobson vs. Hartford Carpet Co.*, 114 U. S. 440, suit was brought upon a patent for a carpet design. The lower court awarded to the complainant as damages an amount equal to the profit it would have made had the carpet in question been sold by it instead of by the defendant. The Supreme Court reversed the lower court, and awarded nominal damages only, holding that the burden was on the complainant of showing what part of its profit was due to the design alone as distinguished from the part due to the carding, spinning, dyeing, and weaving. Such a division of the profit was manifestly impossible. This decision deprived the owners of design patents in all but exceptional cases of any right of money recovery. The injustice of this rule was so palpable that Congress shortly thereafter passed a law providing for a minimum recovery of $250 in suits on design patents.

But the difficulty of the rule is almost equally great in the case of many mechanical patents. Suppose a patent is for an

improvement in an old machine, or device, consisting in adding some new element thereto. The defendant sells or uses the machine as patented and makes a large profit. How much is due to the new element? How much profit would he have made, if he had sold or used merely the old machine? Who can say? How can such a matter be proved with mathematical certainty? In most cases such proof is impossible, and for this reason in most cases there is no substantial recovery.

Or suppose that an infringer has taken the patented device and added some improvement of his own, of more or less value. How can his profit be apportioned between the two? In the case of *Westinghouse Co. vs. Wagner Co.*, 173 Fed. Rep. 361, the patentee had made a valuable improvement in electrical transformers. The defendant company used the patented transformer adding a new feature thereto, and sold $874,000 worth of the infringing devices. The master found that the defendant's profits amounted to about $134,000 and awarded this sum to complainant. The lower court reversed this ruling on the ground that the complainant had not performed the impossible task of proving how much of this profit was due to the complainant's invention and how much to the defendant's improvement, and the Court of Appeals for the Eighth Circuit affirmed this decree. This may be law, but obviously it is not justice. Under this ruling all an infringer has to do to secure himself against a recovery of profits is to add something of his own to the complainant's device, a thing which can be easily done in almost any case.

An examination of all the decisions in patent causes reported in the Supreme Court Reports and the Federal Reporter for the ten years and ten months from Jan. 1, 1901, to November 1, 1911, shows that recoveries were awarded in only twenty-two cases out of the many hundreds that have been decided favorably to the patentees in those years. The total recovery in all these cases amounted to about $190,000, a truly pitiful and ridiculous showing, when we consider the enormous value of the patents involved, and the immense profits which have undoubtedly been realized by their infringers. No patent lawyer can honestly advise his clients that there is any substantial chance of a money recovery in patent suits, save now and then in an exceptional case.

The law should be amended to provide that a complainant may prove any facts and circumstances tending to show the value to

the defendant of the patented device or improvement, or the loss sustained by the complainant, and that the defendant may answer the same, and that the Court or the jury may award to the complainant or plaintiff such sum as it may deem just in view of all such facts and circumstances. This would make the law of recoveries in patent causes conform more nearly to the law of recoveries in other cases of tort, and would remedy a great injustice.

Such a provision is found in the copyright law enacted in 1909. That law provides in Section 25 that the complainant may recover his actual damages, as well as the defendant's profits, " or in lieu of actual damages and profits such damages as to the court shall appear to be just." The copyright law provides further in the same section for minimum and maximum amounts which the Court may allow as damages in its discretion; the maximum allowance being $5000, except in the case of a newspaper reproduction of a copyrighted photograph where the maximum is $250. The complainant may prove his actual damages or defendant's profits, if he chooses to do so, but if he does not do so, the Court may award such damages as may appear to be just upon all the facts and circumstances proven within the limits specified. This law also provides that " in proving profits the plaintiff shall be required to prove sales only, and the defendant shall be required to prove every element of cost which he claims." This is in marked contrast with the illiberality of the patent law, where the burden of proving defendant's cost is thrown upon the complainant.

In the trade-mark law enacted in 1905, it is provided in Section 19 that " the complainant shall be entitled to recover, in addition to the profits to be accounted for by the defendant, the damages complainant has sustained " by the infringement, and further, as in the copyright law, that " in assessing profits the plaintiff shall be required to prove defendant's sales only; defendant must prove all elements of cost which are claimed."

It is interesting to note in this connection that in Germany, as I am informed, a person who knowingly or through gross negligence infringes a patent, is punishable by a fine not exceeding 5000 marks, or by imprisonment not exceeding one year. In lieu of damages, the court may award to the plaintiff a sum not exceeding 10,000 marks.

Procedure in Patent Office

I shall not discuss at length the procedure in the Patent Office but shall merely refer to a few features of the present practice or organization which in my judgment should be changed.

The number of appeals in the Patent Office should be reduced. At present when an application has been rejected by the Primary Examiner on the merits, an appeal can be taken to a Board consisting of three Examiners-in-Chief; if the decision of the Board is adverse, an appeal can be taken to the Commissioner and from his decision, if adverse, an appeal lies to the Court of Appeals of the District of Columbia, making three appeals in all. There is no justification for so many appeals.

Nor is this all. If an applicant has been defeated in all these tribunals, he may, under the provisions of Section 4915 of the Revised Statutes, file a bill in equity in a Federal Court, and may bring in adverse parties and the Commissioner, and take testimony to show he is entitled to the patent. If the court decides in his favor, the Commissioner must issue the patent unless an appeal is taken to the U. S. Circuit Court of Appeals. In case the decision is affirmed on appeal, the patent must be issued. This in effect gives two additional appeals, making five in all.

In *ex parte* applications, the appeal to the Court of Appeals of the District of Columbia should be abolished. The Commissioner's decision should be final. If the applicant desires to contest the matter further, he can then file his bill in equity and testimony can be taken and the Court can decide upon the evidence. The applicant's rights are fully secured in this way. It is a mistake in my judgment to allow an appeal in such cases to a court composed of lawyers without technical training, and to compel them to decide difficult technical questions without the assistance of any evidence whatever.

In interferences, where the question is simply whether one party or another made the invention first, and where evidence is taken in the usual way, an appeal to the Court on this single question of priority is a reasonable procedure; but one appeal should be eliminated. There should be an appeal from the decision of the Board in interferences directly to the Court, and the appeal to the Commissioner in such cases should be abolished.

The present practice in interferences has become so complicated that the delays and expense resulting therefrom are almost

intolerable. Years are sometimes consumed before these interferences are finally determined, and then the struggle is merely transferred to the courts to be fought all over again. The variety of motions and petitions that an ingenious attorney can devise, for purposes legitimate or otherwise, is certainly astonishing and distressing to one who desires a prompt decision of his rights. This practice should be simplified and made to conform more nearly to the practice of a Court of Equity.

As an illustration I shall cite one point in which such simplification might be secured.

Under the present procedure, when an interference is declared, the Examiner of Interferences takes jurisdiction of the case. A motion to dissolve may then be made by either party upon a variety of grounds specified in Rule 122. Such motions, if in proper form, are sent to the Primary Examiner for determination, and from his decision an appeal may be taken in certain cases to the Board, and in other cases directly to the Commissioner. If the motion to dissolve is finally denied, the case goes back to the Examiner of Interferences again. A year or more may be consumed in this manner before the trial of the case really begins before the Examiner of Interferences. This should be changed. When an interference is once declared, and the Examiner of Interferences acquires jurisdiction, he should retain it for all purposes until he has fully disposed of it in one way or another. All motions should be made before him, and decided by him. A motion to dissolve is in effect a demurrer or a motion for judgment on the record. If sustained, the case should be dissolved, or a judgment of priority entered according to the nature of the decision. If the decision is upon the merits holding that a claim is unpatentable or that one of the parties has no right to make the claim, or that the claims have different meanings in the different cases, there should be an appeal to the Board to be heard *inter partes*, and if it affirms the decision, there should be a further *inter partes* appeal to the Commissioner. If the Examiner's decision dissolving the interference is not on the merits but is based on the ground that there has been some irregularity in declaring the same, one appeal would certainly be enough and that should be directly to the Commissioner.

If the motion to dissolve is denied by the Examiner of Interferences, or by the Board or Commissioner on appeal, the case should proceed before the Examiner of Interferences until finally

determined by him upon evidence. From this decision there should be an appeal to the Board, and then an appeal from the Board to the Court. All other motions, such as motions to shift the burden of proof, could be heard by the Examiner of Interferences at the same time. In this way the Examiner of Interferences would have entire control of the case until it was finally disposed of by him. He would have charge of everything that was done in the case and could control it and see that it was diligently prosecuted. Moreover the consideration of the motion to dissolve would acquaint the Examiner of Interferences with the issues involved and in a measure prepare him for the further consideration of the case if it is finally decided that the interference must proceed.

In support of the present practice, it is argued that the Primary Examiner is better acquainted with the particular art in question, and, therefore, better qualified to pass on the questions raised by a motion to dissolve. But the Examiner of Interferences has to pass on the question of priority and questions ancillary thereto, if the interference proceeds, and, if he is qualified to do this, he is qualified to decide motions to dissolve. On motions to dissolve, the issues are limited and definite, and their determination does not require a knowledge of the entire art. At any rate the advantages of the proposed method outweigh in my judgment any disadvantage that might flow from any difference in the qualifications of the two tribunals.

In conclusion I again urge the importance of proceeding with reasonable caution in the amendment of the law. Let us have no hesitation in correcting acknowledged defects, but let us be careful to avoid new schemes of improvement so radical in their nature that there is nothing in past experience to afford any reliable means of determining whether they will work for good or for evil.

Discussion

Prof. James R. Withrow:

Desirable Modifications of the United States Patent Laws

One of the important failings in the United States Patent Laws (which are recognized as an excellent code), is the fact that an inventor is constrained to rigorously define his invention and its claims at the

conclusion of his description. In case the inventor should be mistaken in his opinion as to what his invention exactly consists of, the subsequent court proceedings in many cases result in his being confined to the advantages which arise from what he has actually defined and not to the things which he thought he was defining. The law should therefore be that an inventor should at the close of his description state what he believes to be his invention, the public being warned to this extent at least, not to trespass. Then the courts should subsequently decide whether he is entitled to the protection to which he *believes* he is entitled.

The second point, one not nearly so important, perhaps, relates to the abuse of the advantages which foreign inventors have at the present time. For instance a foreign inventor of any pharmaceutical preparation is said to be able to secure letters patent in the United States which he may then sell to a foreign manufacturer who thus having a monopoly may prohibit entirely the production of the article in this country. Then no matter what tariff may be placed upon the article if it is demanded by the public in this country the manufacturer in Europe is able to produce the product and sell it at whatever price he chooses. It is suggested that this may be overcome, not by the erroneous notion that the inventor should be compelled to place his invention in operation within a given time, which would be a real hardship to most American inventors, but by compelling foreigners to accept a righteously decided royalty from any manufacturer or manufacturers who care to produce his product in this country. Under this system of *enforced royalty acceptance* a commission should be appointed to see that the holder of the patent receives a just compensation for the license granted.

REPORT OF COMMITTEE ON PATENTS

By WM. M. GROSVENOR

Read at Washington Meeting, Dec. 22, 1911

Gentlemen:

At the Chicago Meeting of the American Institute of Chemical Engineers, held on the 23d day of last June, a resolution was offered by Dr. Sadtler, seconded by Dr. Gudeman and carried creating a Patent Committee.

Drs. Grosvenor, Sadtler and Gudeman were appointed.

At that time a number of suggestions were made for consideration. Mr. Gutmann of St. Louis forwarded through the kindness of our President, Dr. Frerichs, a resolution for transmission to the President of the United States, which had been passed by the St. Louis Section of the American Institute of Electrical Engineers and other socities, urging the need of patent reform.

When, at the Chicago Meeting it became apparent that the mid-winter meeting of the Institute would be held in Washington, it seemed particularly desirable that some study should be given the matter prior to this meeting and that, at the meeting itself, effort be made to present for your consideration the most expert views obtainable upon this subject. It was the feeling of the majority of your Committee that no definite action toward addressint the President should be taken prior to this December meeting. Their activity was at first devoted to ascertaining and considering the action which had been taken by various other societies with a view to presenting at this meeting a more complete outline of the questions to be considered and of submitting for your action a definite form of resolution to be presented to the President.

Your Committee addressed to 150 other organizations, the following list of questions as to their patent work.

" For the benefit of the Patent Committee of the American Institute of Chemical Engineers, permit me to inquire regarding your organization:

"1. Have you been addressed by any other organization urging action looking toward a revision of the U. S. Patent System, and if so, by whom?

"2. Have you considered such action favorably or unfavorably?

"3. Have you sought the advice of any experts or of other organizations in this matter, and if so, from whom?

"4. Have you endeavored to co-operate with others in any manner to this end?

"5. Has any action been taken toward memorializing the President or Congress on the subject either by your organization or any other so far as you are informed?

"6. If any particular reforms are advocated by your organization, a brief outline of them will be much appreciated."

A tabulation of their replies need not be given, but the important point is that only 6 have considered the matter at all and only 4 have taken any action. Not one has sought expert advice except the Inventors Guild from one man on one occasion and they have not been sufficiently interested to answer.

At this time Mr. Gutmann wrote the Chairman strongly urging that action be taken without delay. The questions raised by Dr. Gutmann seemed too important for the decision of any small group of members and, while the phraseology of the resolution was perhaps not the most desirable, your Committee did not feel disposed to begin with criticism, particularly as one member felt that the phrasing of the resolution was a matter of small importance. The intent seemed clear and it was thought best to submit it to the Society at large.

While 90 per cent of the replies approved the resolution, severe criticism arose. It came from the men best fitted to judge, from those whose opinion the Institute could ill afford to disregard. Needless to say, your Committee was not prepared with a detailed arraignment of all abuses or a panacea for all ills. Within the Committee itself there is difference of opinion as to what is objectionable and even greater difference as to the best remedies to be applied. The resolution demanded appeared to us difficult to frame. To be accurate in criticism and wise in suggestion, expert advice was needed and time for considering it carefully.

Consequently but one course seemed open to your Committee and the following form of resolution was drafted:

To the President of the United States.

"*Whereas*, the United States Patent Laws despite many revisions continue to cause great suffering, injustice and loss to the People of the United States and the Industries of our country, and

"*Whereas*, it is very desirable to increase the security and value of industrial property by appropriate legislation,

"*Be it resolved that we, the American Institute of Chemical Engineers* in regular meeting assembled respectfully request that, in the next and subsequent messages to Congress, attention be called specifically to existing conditions, and the Congress be urged to establish a Patent Commission, invested with power and provided with funds to investigate thoroughly said conditions and recommend suitable legislation for correcting the evils."

Even in this resolution, the writer personally believes we have gone too far. The more the matter is examined into, the more it appears to him that the laws are not responsible for much if any of the hardship, but rather the inadequate facilities and improper practice and rules that have grown up around the law like barnacles, and seaweed about a well formed pier. Our forefathers builded better perhaps than they knew, certainly than we have administered.

Your committee felt that one of the best ways of crystallizing intelligent opinion on the subject was to invite experts in the particular phases of patent work to recount their experiences, give us their opinions and recommend specific action at a time and in a manner that could be transmitted to the Institute at large and form a basis for criticism of any form of resolution which might be prepared later by your Committee.

The Meetings Committee decided to devote a part of this session to the purpose and some of the most eminent advisers in the country have accepted the invitation. Opportunity has been courteously given us to visit and inspect in detail the present patent office equipment and building, and your Committee urges every member to do so thoroughly. Finally, one of the largest and best known firms of patent lawyers will lay before us what, I am told, is not merely a personal expression of opinion, but the composite opinion of that office systematized under the direction of its heads and crystallized into certain recommendations which are the result of many years of aggregate experience in the practice of patent law.

It will be neither possible nor desirable for us to digest this all at once. Others have been striving for years to impress the

Congress with the need of certain so-called "reforms." The few primary facts made public in the reports of the Commission of Patents demand attention. The Patent Office is one of the few departments that has the record of placing behind bars its first and only grafter in 117 years and of not requiring a cent of public support. The profits turned over to the Treasury aggregate more than $7,000,000. The average surplus for ten years has been over $170,000, and to quote the Commissioner, "it has all been paid by the inventors." Contrary to the impression of many lawyers, of the $1,987,700 received last year, more than $1,750,000, or about 90 per cent, was paid in application or issue fees. Certainly it would seem as though the inventor had a right to demand adequate facilities for economically transacting the business for which he pays. And yet the Congress has not granted adequate convenience for prompt and efficient handling of this profitable business, sanitary quarters or proper salaries for employees who should be highly educated technically, or even a safe storage for millions of dollars worth of documents that could hardly be replaced at any price. It should not be criticised for failure to pass with promptness every "reform bill" (far otherwise) but might well be urged to show more interest in devising and in passing promptly measures for simplification, economy, and safety.

At present, therefore, your Committee has nothing to recommend except receptive attention to the experts who will advise us, prompt distribution of information to all our members and to others who should be interested, serious discussion and carefully considered decision what we can do and a steady, purposeful pursuit of the policies upon which we unite, by every means in our power—by resolution to the President, and to the Congress, by personal appeal to representatives, by education of voters and influential constituents, by urging all to exercise their influence in support of the movement and perhaps by a magazine publicity campaign. If possible, let all technical and legal bodies unite upon such action as can be agreed upon by all and relentlessly pursue this limited but probably more essential program, until it is finally adopted.

Meanwhile, not only is the inventor deprived of justice—he is only perhaps 5 per cent of the population—but every individual man, woman and child in the land suffers by the needless delay, expense and uncertainty in the progress of industry.

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